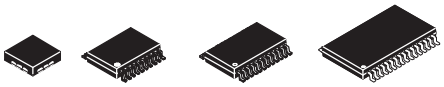





# ExpressCard™ POWER INTERFACE SWITCH

## FEATURES

- **Meets the ExpressCard™ Standard (ExpressCard|34 or ExpressCard|54)**
- **Compliant with the ExpressCard™ Compliance Checklists**
- **Fully Satisfies the ExpressCard™ Implementation Guidelines**
- **Supports Systems with WAKE Function**
- **TTL-Logic Compatible Inputs**
- **Short Circuit and Thermal Protection**
- **–40°C to 85°C Ambient Operating Temperature Range**
- **Available in a 20-pin TSSOP, a 20-pin QFN, or 24-pin PowerPAD™ HTSSOP (Single)**
- **Available in a 32-pin PowerPAD™ HTSSOP (Dual)**

## APPLICATIONS

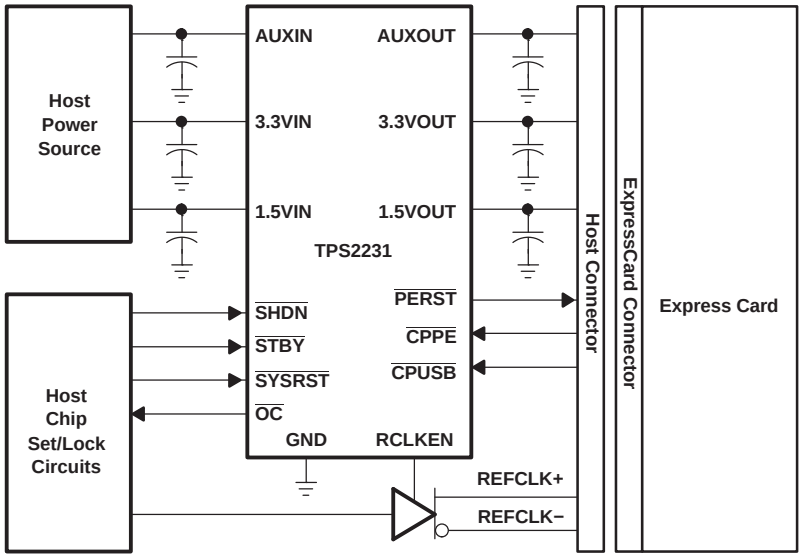
- **Notebook Computers**
- **Desktop Computers**
- **Personal Digital Assistants (PDAs)**
- **Digital Cameras**
- **TV and Set Top Boxes**

## DESCRIPTION

The TPS2231 and TPS2236 ExpressCard power interface switches provide the total power management solution required by the ExpressCard specification. The TPS2231 and TPS2236 ExpressCard power interface switches distribute 3.3 V, AUX, and 1.5 V to the ExpressCard socket. Each voltage rail is protected with integrated current-limiting circuitry.

The TPS2231 supports systems with single-slot ExpressCard|34 or ExpressCard|54 sockets. The TPS2236 supports systems with dual-slot ExpressCard sockets.

End equipment for the TPS2231 and TPS2236 include notebook computers, desktop computers, personal digital assistants (PDAs), and digital cameras.




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.

PowerPAD is a trademark of Texas Instruments.
ExpressCard is a trademark of Personal Computer Memory Card International Association.

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.

## AVAILABLE OPTIONS

| $T_A$ | NUMBER OF CHANNELS | PACKAGED DEVICES(1)(2) | | |
|---|---|---|---|---|
| | | TSSOP | PowerPAD HTSSOP | QFN |
| –40°C to 85°C | Single | TPS2231PW | TPS2231PWP | TPS2231RGP |
| | | | | TPS2231MRGP(3) |
| | | | | TPS2231MRGP-1(4) |
| | | | | TPS2231MRGP-2(5) |
| | Dual | | TPS2236DAP | |

(1) The package is available taped and reeled. Add an R suffix to device types (e.g., TPS2231PWPR).
(2) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI website at www.ti.com.
(3) The TPS2231MRGP is identical to the TPS2231 with the exception of the PowerPAD dimensions. See the Thermal Pad Mechanical data portion of this data sheet for specific information. The thermal pad for the TPS2231MRGP and TPS2231MRGP-1 is 2,2 mm × 2,2 mm; the thermal pad for the TPS2231RGP is 2,7 mm × 2,7 mm.
(4) The TPS2231MRGP-1 is identical to the TPS2231MGRP with the exception that the orientation of the part in the reel is rotated 180°. See the Package Materials Information portion of this data sheet for specific information.
(5) The TPS2231MRGP-2 is identical to the TPS2231MRGP with the exception that the orientation of the part in the reel is rotated 90° and does not have an internal pull-up resistor betweeen AUX IN and $\overline{\text{SYSRST}}$. See the Package Materials Information portion of this data sheet for specific information.

## ABSOLUTE MAXIMUM RATINGS

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

| | | | | TPS223x | UNIT |
|---|---|---|---|---|---|
| $V_I$ | Input voltage range for card power | $V_{I(3.3VIN)}$ | | –0.3 to 6 | V |
| | | $V_{I(1.5VIN)}$ | | –0.3 to 6 | V |
| | | $V_{I(AUXIN)}$ | | –0.3 to 6 | V |
| | Logic input/output voltage | | | –0.3 to 6 | V |
| $V_O$ | Output voltage range | $V_{O(3.3VOUT)}$ | | –0.3 to 6 | V |
| | | $V_{O(1.5VOUT)}$ | | –0.3 to 6 | V |
| | | $V_{O(AUXOUT)}$ | | –0.3 to 6 | V |
| | Continuous total power dissipation | | | See Dissipation Rating Table | |
| $I_O$ | Output current | $I_{O(3.3VOUT)}$ | | Internally limited | |
| | | $I_{O(AUXOUT)}$ | | Internally limited | |
| | | $I_{O(1.5VOUT)}$ | | Internally limited | |
| | $\overline{\text{OC}}$ sink current | | | 10 | mA |
| | $\overline{\text{PERST}}$ sink/source current | | | 10 | mA |
| $T_J$ | Operating virtual junction temperature range | | | –40 to 120 | °C |
| $T_{stg}$ | Storage temperature range | | | –55 to 150 | °C |
| | Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds | | | 260 | °C |
| ESD | Electrostatic discharge protection | Human body model (HBM) MIL-STD-883C | TPS2231 | 2 | kV |
| | | | TPS2236, all pins except $\overline{\text{PERSTx}}$ and $\overline{\text{OCx}}$ | | |
| | | | TPS2236, $\overline{\text{PERSTx}}$ and $\overline{\text{OCx}}$ | 1.5 | kV |
| | | Charge device model (CDM) | | 500 | V |

(1) Stresses beyond those listed under *absolute maximum ratings* may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under *recommended operating conditions* is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

## DISSIPATION RATINGS (Thermal Resistance = °C/W)

| PACKAGE | $T_A$ ≤ 25°C POWER RATING | DERATING FACTOR ABOVE $T_A$ = 25°C | $T_A$ = 70°C POWER RATING | $T_A$ = 85°C POWER RATING |
|---|---|---|---|---|
| PW (20)(1) | 704.2 mW | 7.41 mW/°C | 370.6 mW | 259.5 mW |
| PWP (24)(1) | 3153 mW | 33.19 mW/°C | 1659.5 mW | 1161.6 mW |
| RGP (20) (2) | 3277.5 mW | 34.5 mW/°C | 1725 mW | 1207.3 mW |
| DAP (32) (1) PowerPAD not soldered down | 993.4 mW | 10.46 mW/°C | 522.8 mW | 366 mW |
| DAP (32)(1) | 4040.8 mW | 42.55 mW/°C | 2126.8 mW | 1488.7 mW |

(1) These devices are mounted on an JEDEC low-k board (2-oz. traces on surface), (The table is assuming that the maximum junction temperature is 120°C). The power pad on the device must be soldered down to the power pad on the board if best thermal performance is needed.
(2) Tis device is mounted on a JEDEC JESO51.5 high-k board (2 signal, 2 plane). The values assume a maxium junction temperature of 120°C.

## RECOMMENDED OPERATING CONDITIONS

| | | | MIN | MAX | UNIT |
|---|---|---|---|---|---|
| $V_{I(3.3VIN)}$ | Input voltage | 3.3VIN is only required for its respective functions | 3 | 3.6 | V |
| $V_{I(1.5VIN)}$ | | 1.5VIN is only required for its respective functions | 1.35 | 1.65 | |
| $V_{I(AUXIN)}$ | | AUXIN is required for all circuit operations | 3 | 3.6 | |
| $I_{O(3.3VOUT)}$ | Continuous output current | $T_J$ = 120°C | 0 | 1.3 | A |
| $I_{O(1.5VOUT)}$ | | | 0 | 650 | mA |
| $I_{O(AUXOUT)}$ | | | 0 | 275 | mA |
| $T_J$ | Operating virtual junction temperature | | –40 | 120 | °C |

## ELECTRICAL CHARACTERISTICS

$T_J$ = 25°C, $V_{I(3.3VIN)}$ = $V_{I(AUXIN)}$ = 3.3 V, $V_{I(1.5VIN)}$ = 1.5 V, $V_{I(/SHDNx)}$, $V_{I(/STBYx)}$ = 3.3 V, $V_{I(/CPPEx)}$ = $V_{I(/CPUSBx)}$ = 0 V, $V_{I(/SYSRST)}$ = 3.3 V, $\overline{OCx}$ and RCLKENx and $\overline{PERSTx}$ are open, all voltage outputs unloaded (unless otherwise noted)

| PARAMETER | | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|---|
| **POWER SWITCH** | | | | | | | |
| | Power switch resistance | 3.3VIN to 3.3VOUT with two switches on for dual | $T_J$ = 25°C, I = 1300 mA each | | 45 | | mΩ |
| | | | $T_J$ = 100°C, I = 1300 mA each | | | 68 | |
| | | 1.5VIN to 1.5VOUT With two switches on for dual | $T_J$ = 25°C, I = 650 mA each | | 46 | | mΩ |
| | | | $T_J$ = 100°C, I = 650 mA each | | | 70 | |
| | | AUXIN to AUXOUT with two switches on for dual | $T_J$ = 25°C, I = 275 mA each | | 120 | | mΩ |
| | | | $T_J$ = 100°C, I = 275 mA each | | | 200 | |
| $R_{(DIS\_FET)}$ | Discharge resistance on 3.3V/1.5V/AUX outputs | | $V_{I(/SHDNx)}$ = 0 V, $I_{(discharge)}$ = 1 mA | 100 | | 500 | Ω |
| $I_{OS}$ | Short-circuit output current(1) | $I_{OS(3.3VOUT)}$ (steady-state value) | $T_J$ (–40, 120°C]. Output powered into a short | 1.35 | 2 | 2.5 | A |
| | | $I_{OS(1.5VOUT)}$ (steady-state value) | | 0.67 | 1 | 1.3 | A |
| | | $I_{OS(AUXOUT)}$(steady-state value) | | 275 | 450 | 600 | mA |
| | Thermal shutdown | Trip point, $T_J$ | Rising temperature, not in overcurrent condition | 155 | 165 | | °C |
| | | | Overcurrent condition | 120 | 130 | | |
| | | Hysteresis | | | 10 | | |
| | Current-limit response time | From short to the 1st threshold within 1.1 times of final current limit, $T_J$ = 25°C | $V_{O(3.3VOUT)}$ with 100-mΩ short | | 43 | 100 | µs |
| | | | $V_{O(1.5VOUT)}$ with 100-mΩ short, TPS2231 | | 100 | 140 | |
| | | | $V_{O(1.5VOUT)}$ with 100-mΩ short, TPS2236 | | 110 | 150 | |
| | | | $V_{O(AUXOUT)}$ with 100-mΩ short | | 38 | 100 | |

(1) Pulse-testing techniques maintain junction temperature close to ambient temperature; thermal effects must be taken into account separately.

## ELECTRICAL CHARACTERISTICS (continued)

$T_J$ = 25°C, $V_{I(3.3VIN)}$ = $V_{I(AUXIN)}$ = 3.3 V, $V_{I(1.5VIN)}$ = 1.5 V, $V_{I(/SHDNx)}$, $V_{I(STBYx)}$ = 3.3 V, $V_{I(/CPPEx)}$ = $V_{I(/CPUSBx)}$ = 0 V, $V_{I(/SYSRST)}$ = 3.3 V, $\overline{OCx}$ and RCLKENx and $\overline{PERSTx}$ are open, all voltage outputs unloaded (unless otherwise noted)

| PARAMETER | | | | TEST CONDITIONS | | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|---|---|---|
| $I_I$ | Operation input quiescent current | Normal operation of TPS2236 | $I_{I(AUXIN)}$ | Outputs are unloaded, $T_J$ [–40, 120°C] (does not include $\overline{CPPEx}$ and $\overline{CPUSBx}$ logic pullup currents) | | | 125 | 200 | µA |
| | | | $I_{I(3.3VIN)}$ | | | | 17.5 | 25 | |
| | | | $I_{I(1.5VIN)}$ | | | | 5.5 | 15 | |
| | | Normal operation of TPS2231 | $I_{I(AUXIN)}$ | | | | 85 | 150 | µA |
| | | | $I_{I(3.3VIN)}$ | | | | 10 | 15 | |
| | | | $I_{I(1.5VIN)}$ | | | | 2.5 | 10 | |
| $I_I$ | Total input quiescent current | Normal operation of TPS2236 | $I_{I(AUXIN)}$ | Outputs are unloaded, $T_J$[–40, 120°C] (include $\overline{CPPEx}$ and $\overline{CPUSBx}$ logic pullup currents) | | | 200 | 320 | µA |
| | | | $I_{I(3.3VIN)}$ | | | | 17.5 | 25 | |
| | | | $I_{I(1.5VIN)}$ | | | | 5.5 | 15 | |
| | | Normal operation of TPS2231 | $I_{I(AUXIN)}$ | | | | 120 | 210 | µA |
| | | | $I_{I(3.3VIN)}$ | | | | 10 | 15 | |
| | | | $I_{I(1.5VIN)}$ | | | | 2.5 | 10 | |
| | | Shutdown mode of TPS2236 | $I_{I(AUXIN)}$ | $\overline{CPUSB}$ = $\overline{CPPE}$ = 0 V $\overline{SHDN}$ = 0 V (discharge FETs are on) (include $\overline{CPPEx}$ and $\overline{CPUSBx}$ logic pullup currents and $\overline{SHDN}$ pullup current) $T_J$ [–40, 120°C] | | | 250 | 440 | µA |
| | | | $I_{I(3.3VIN)}$ | | | | 3.5 | 20 | |
| | | | $I_{I(1.5VIN)}$ | | | | 0.1 | 20 | |
| | | Shutdown mode of TPS2231 | $I_{I(AUXIN)}$ | | | | 144 | 270 | µA |
| | | | $I_{I(3.3VIN)}$ | | | | 3.5 | 10 | |
| | | | $I_{I(1.5VIN)}$ | | | | 0.5 | 10 | |
| $I_{lkg(FWD)}$ | Forward leakage current | TPS2236 | $I_{I(AUXIN)}$ | $\overline{SHDN}$ = 3.3 V, $\overline{CPUSB}$ = $\overline{CPPE}$ = 3.3 V (no card present, discharge FETs are on); current measured at input pins, $T_J$ = 120°C, includes RCLKEN pullup current | | | 40 | 100 | µA |
| | | | $I_{I(3.3VIN)}$ | | | | 0.1 | 100 | |
| | | | $I_{I(1.5VIN)}$ | | | | 0.1 | 100 | |
| | | TPS2231 | $I_{I(AUXIN)}$ | | | | 20 | 50 | µA |
| | | | $I_{I(3.3VIN)}$ | | | | 0.1 | 50 | |
| | | | $I_{I(1.5VIN)}$ | | | | 0.1 | 50 | |
| $I_{lkg(RVS)}$ | Reverse leakage current (TPS2236 and TPS2231) | $I_{I(AUXOUT)}$ | $T_J$ = 25°C | $V_{O(AUXOUT)}$ = $V_{O(3.3VOUT)}$= 3.3 V; $V_{O(1.5VOUT)}$ = 1.5 V; All voltage inputs are grounded (current measured from output pins going in) | | | 0.1 | 10 | µA |
| | | | $T_J$ = 120°C | | | | | 50 | |
| | | $I_{I(3.3VOUT)}$ | $T_J$ = 25°C | | | | 0.1 | 10 | µA |
| | | | $T_J$ = 120°C | | | | | 50 | |
| | | $I_{I(1.5VOUT)}$ | $T_J$ = 25°C | | | | 0.1 | 10 | µA |
| | | | $T_J$ = 120°C | | | | | 50 | |
| **LOGIC SECTION ($\overline{SYSRST}$, $\overline{SHDNx}$, $\overline{STBYx}$, $\overline{PERSTx}$, RCLKENx, $\overline{OCx}$, $\overline{CPUSBx}$, $\overline{CPPEx}$)** | | | | | | | | | |
| | Logic input supply current | $I_{(\overline{SYSRST})}$ | Input | $\overline{SYSRST}$ = 3.6 V, sinking | | | 0 | 1 | µA |
| | | | | $\overline{SYSRST}$ = 0 V, sourcing | TPS2231-2 | | 0 | 1 | |
| | | | | | TPS2231, TPS2231-1 | 10 | | 30 | |
| | | $I_{(\overline{SHDNx})}$ | Input | $\overline{SHDNx}$ = 3.6 V, sinking | | | 0 | 1 | µA |
| | | | | $\overline{SHDNx}$ = 0 V, sourcing | | 10 | | 30 | |
| | | $I_{(\overline{STBYx})}$ | Input | $\overline{STBYx}$ = 3.6 V, sinking | | | 0 | 1 | µA |
| | | | | $\overline{STBYx}$ = 0 V, sourcing | | 10 | | 30 | |
| | | $I_{(RCLKENx)}$ | Input | RCLKENx = 0 V, sourcing | | 10 | | 30 | µA |
| | | $I_{(\overline{CPUSBx})}$ or $I_{(\overline{CPPEx})}$ | Inputs | $\overline{CPUSB}$ or $\overline{CPPE}$ = 0 V, sinking | | | 0 | 1 | µA |
| | | | | $\overline{CPUSB}$ or $\overline{CPPE}$ = 3.6 V, sourcing | | 10 | | 30 | |
| | Logic input voltage | High level | | | | 2 | | | V |
| | | Low level | | | | | | 0.8 | |
| | RCLEN output low voltage | | Output | $I_{O(RCLKEN)}$ = 60 µA | | | | 0.4 | V |
| | $\overline{PERST}$ assertion threshold of output voltage ($\overline{PERST}$ asserted when any output voltage falls below the threshold) | | | 3.3VOUT falling | | 2.7 | | 3 | V |
| | | | | AUXOUT falling | | 2.7 | | 3 | |
| | | | | 1.5VOUT falling | | 1.2 | | 1.35 | |
| | $\overline{PERST}$ assertion delay from output voltage | | | 3.3VOUT, AUXOUT, or 1.5VOUT falling | | | | 500 | ns |

## ELECTRICAL CHARACTERISTICS (continued)

$T_J$ = 25°C, $V_{I(3.3VIN)}$ = $V_{I(AUXIN)}$ = 3.3 V, $V_{I(1.5VIN)}$ = 1.5 V, $V_{I(/SHDNx)}$, $V_{I(/STBYx)}$ = 3.3 V, $V_{I(/CPPEx)}$ = $V_{I(/CPUSBx)}$ = 0 V, $V_{I(/SYSRST)}$ = 3.3 V, $\overline{OC}$x and RCLKENx and $\overline{PERST}$x are open, all voltage outputs unloaded (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| | $\overline{PERST}$ de-assertion delay from output voltage | 3.3VOUT, AUXOUT, and 1.5VOUT rising within tolerance | 4 | 10 | 20 | ms |
| | $\overline{PERST}$ assertion delay from $\overline{SYSRST}$ | Max time from $\overline{SYSRST}$ asserted or de-asserted | | | 500 | ns |
| $t_{W(PERST)}$ | $\overline{PERST}$ minimum pulse width | 3.3VOUT, AUXOUT, or 1.5VOUT falling out of tolerance or triggered by $\overline{SYSRST}$ | 100 | 250 | | µs |
| | $\overline{PERST}$ output low voltage | $I_{O(PERST)}$ = 500 µA | | | 0.4 | V |
| | $\overline{PERST}$ output high voltage | | 2.4 | | | V |
| | $\overline{OC}$ output low voltage | $I_{O(/OC)}$ = 2 mA | | | 0.4 | V |
| | $\overline{OC}$ leakage current | $V_{O(/OC)}$ = 3.6 V | | | 1 | µA |
| | $\overline{OC}$ deglitch | Falling into or out of an overcurrent condition | 6 | | 20 | mS |
| **UNDERVOLTAGE LOCKOUT (UVLO)** | | | | | | |
| | 3.3VIN UVLO | 3.3VIN level, below which 3.3VIN and 1.5VIN switches are off | 2.6 | | 2.9 | V |
| | 1.5VIN UVLO | 1.5VIN level, below which 3.3VIN and 1.5VIN switches are off | 1 | | 1.25 | |
| | AUXIN UVLO | AUXIN level, below which all switches are off | 2.6 | | 2.9 | |
| | UVLO hysteresis | | | 100 | | mV |

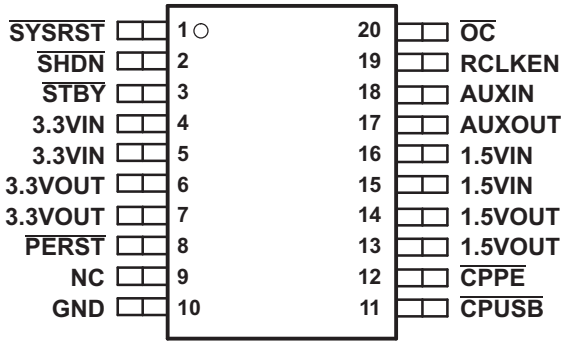
## SWITCHING CHARACTERISTICS

$T_J$ = 25°C, $V_{I(3.3VIN)}$ = $V_{I(AUXIN)}$ = 3.3 V, $V_{I(1.5VIN)}$ = 1.5 V, $V_{I(/SHDNx)}$, $V_{I(/STBYx)}$ = 3.3 V, $V_{I(/CPPEx)}$ = $V_{I(/CPUSBx)}$ = 0 V, $V_{I(/SYSRST)}$ = 3.3 V, $\overline{OCx}$ and RCLKENx and $\overline{PERSTx}$ are open, all voltage outputs unloaded (unless otherwise noted)

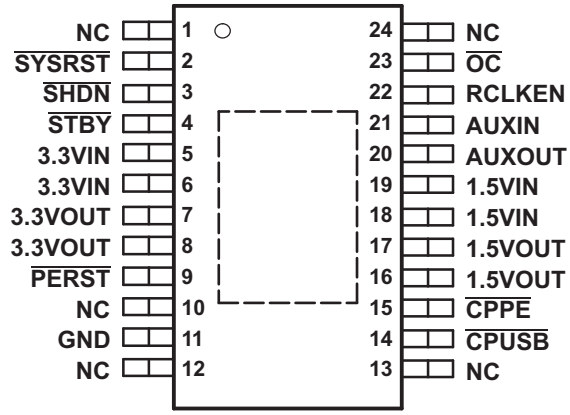
| PARAMETER | | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|---|
| $t_r$ | Output rise times | 3.3VIN to 3.3VOUT | $C_{L(3.3VOUT)}$ = 0.1 µF, $I_{O(3.3VOUT)}$ = 0 A | 0.1 | | 3 | ms |
| | | AUXIN to AUXOUT | $C_{L(AUXOUT)}$ = 0.1 µF, $I_{O(AUXOUT)}$ = 0 A | 0.1 | | 3 | |
| | | 1.5VIN to 1.5VOUT | $C_{L(1.5VOUT)}$ = 0.1 µF, $I_{O(1.5VOUT)}$ = 0 A | 0.1 | | 3 | |
| | | 3.3VIN to 3.3VOUT | $C_{L(3.3VOUT)}$ = 100 µF, $R_L$ = $V_{I(3.3VIN)}$/1 A | 0.1 | | 6 | |
| | | AUXIN to AUXOUT | $C_{L(AUXOUT)}$ = 100 µF, $R_L$ = $V_{I(AUXIN)}$/0.250 A | 0.1 | | 6 | |
| | | 1.5VIN to 1.5VOUT | $C_{L(1.5VOUT)}$ = 100 µF, $R_L$ = $V_{I(1.5VIN)}$/0.500 A | 0.1 | | 6 | |
| $t_f$ | Output fall times when card removed (both $\overline{CPUSB}$ and $\overline{CPPE}$ de-asserted) | 3.3VIN to 3.3VOUT | $C_{L(3.3VOUT)}$ = 0.1 µF, $I_{O(3.3VOUT)}$ = 0 A | 10 | | 150 | µs |
| | | AUXIN to VAUXOUT | $C_{L(AUXOUT)}$ = 0.1 µF, $I_{O(AUXOUT)}$ = 0 A | 10 | | 150 | |
| | | 1.5VIN to 1.5VOUT | $C_{L(1.5VOUT)}$ = 0.1 µF, $I_{O(1.5VOUT)}$ = 0 A | 10 | | 150 | |
| | | 3.3VIN to 3.3VOUT | $C_{L(3.3VOUT)}$ = 20 µF, $I_{O(3.3VOUT)}$ = 0 A | 2 | | 30 | ms |
| | | AUXIN to VAUXOUT | $C_{L(AUXOUT)}$ = 20 µF, $I_{O(AUXOUT)}$ = 0 A | 2 | | 30 | |
| | | 1.5VIN to 1.5VOUT | $C_{L(1.5VOUT)}$ = 20 µF, $I_{O(1.5VOUT)}$ = 0 A | 2 | | 30 | |
| $t_f$ | Output fall times when $\overline{SHDN}$ asserted (card is present) | 3.3VIN to 3.3VOUT | $C_{L(3.3VOUT)}$ = 0.1 µF, $I_{O(3.3VOUT)}$ = 0 A | 10 | | 150 | µs |
| | | AUXIN to VAUXOUT | $C_{L(AUXOUT)}$ = 0.1 µF, $I_{O(AUXOUT)}$ = 0 A | 10 | | 150 | |
| | | 1.5VIN to 1.5VOUT | $C_{L(1.5VOUT)}$ = 0.1 µF, $I_{O(1.5VOUT)}$ = 0 A | 10 | | 150 | |
| | | 3.3VIN to 3.3VOUT | $C_{L(3.3VOUT)}$ = 100 µF, $R_L$ = $V_{I(3.3VIN)}$/1 A | 0.1 | | 5 | ms |
| | | AUXIN to VAUXOUT | $C_{L(AUXOUT)}$ = 100 µF $R_L$ = $V_{I(AUXIN)}$/0.250 A | 0.1 | | 5 | |
| | | 1.5VIN to 1.5VOUT | $C_{L(1.5VOUT)}$ = 100 µF, $R_L$ = $V_{I(1.5VIN)}$/0.500 A | 0.1 | | 5 | |
| $t_{pd(on)}$ | Turn-on propagation delay | 3.3VIN to 3.3VOUT | $C_{L(3.3VOUT)}$ = 0.1 µF, $I_{O(3.3VOUT)}$ = 0 A | 0.1 | | 1 | ms |
| | | AUXIN to VAUXOUT | $C_{L(AUXOUT)}$ = 0.1 µF, $I_{O(AUXOUT)}$ = 0A | 0.05 | | 0.5 | |
| | | 1.5VIN to 1.5VOUT | $C_{L(1.5VOUT)}$ = 0.1 µF, $I_{O(1.5VOUT)}$ = 0 A | 0.1 | | 1 | |
| | | 3.3VIN to 3.3VOUT | $C_{L(3.3VOUT)}$ = 100 µF, $R_L$ = $V_{I(3.3VIN)}$/1 A | 0.1 | | 1.5 | |
| | | AUXIN to VAUXOUT | $C_{L(AUXOUT)}$ = 100 µF, $R_L$ = $V_{I(AUXIN)}$/0.250 A | 0.05 | | 1 | |
| | | 1.5VIN to 1.5VOUT | $C_{L(1.5VOUT)}$ = 100 µF, $R_L$ = $V_{I(1.5VIN)}$/0.500 A | 0.1 | | 1.5 | |
| $t_{pd(off)}$ | Turn-off propagation delay | 3.3VIN to 3.3VOUT | $C_{L(3.3VOUT)}$ = 0.1 µF, $I_{O(3.3VOUT)}$ = 0 A | 0.1 | | 1.5 | ms |
| | | AUXIN to VAUXOUT | $C_{L(AUXOUT)}$ = 0.1 µF, $I_{O(AUXOUT)}$ = 0 A | 0.05 | | 0.5 | |
| | | 1.5VIN to 1.5VOUT | $C_{L(1.5VOUT)}$ = 0.1 µF, $I_{O(1.5VOUT)}$ = 0 A | 0.1 | | 1.5 | |
| | | 3.3VIN to 3.3VOUT | $C_{L(3.3VOUT)}$ = 100 µF, $R_L$ = $V_{I(3.3VIN)}$/1 A | 0.1 | | 1.5 | |
| | | AUXIN to VAUXOUT | $C_{L(AUXOUT)}$ = 100 µF, $R_L$ = $V_{I(AUXIN)}$/0.250 A | 0.05 | | 0.5 | |
| | | 1.5VIN to 1.5VOUT | $C_{L(1.5VOUT)}$ = 100 µF, $R_L$ = $V_{I(1.5VIN)}$/0.500 A | 0.1 | | 1 | |

## PIN ASSIGNMENTS

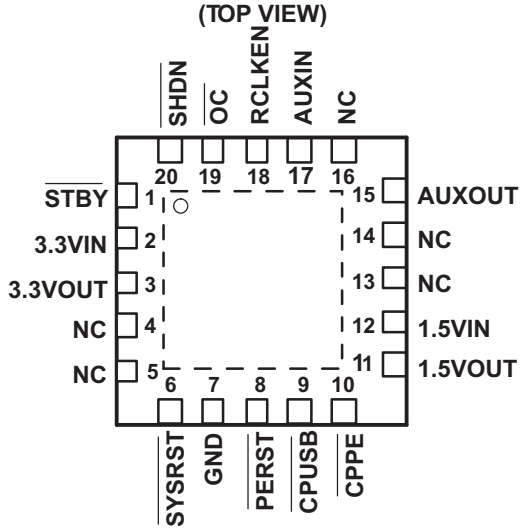
TPS2231
PW PACKAGE
(TOP VIEW)



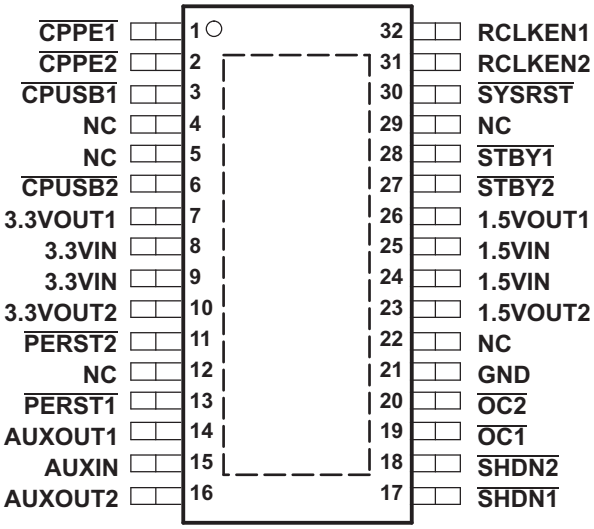

TPS2231
PWP PACKAGE
(TOP VIEW)




TPS2231
RGP PACKAGE
(TOP VIEW)




TPS2236
DAP PACKAGE
(TOP VIEW)



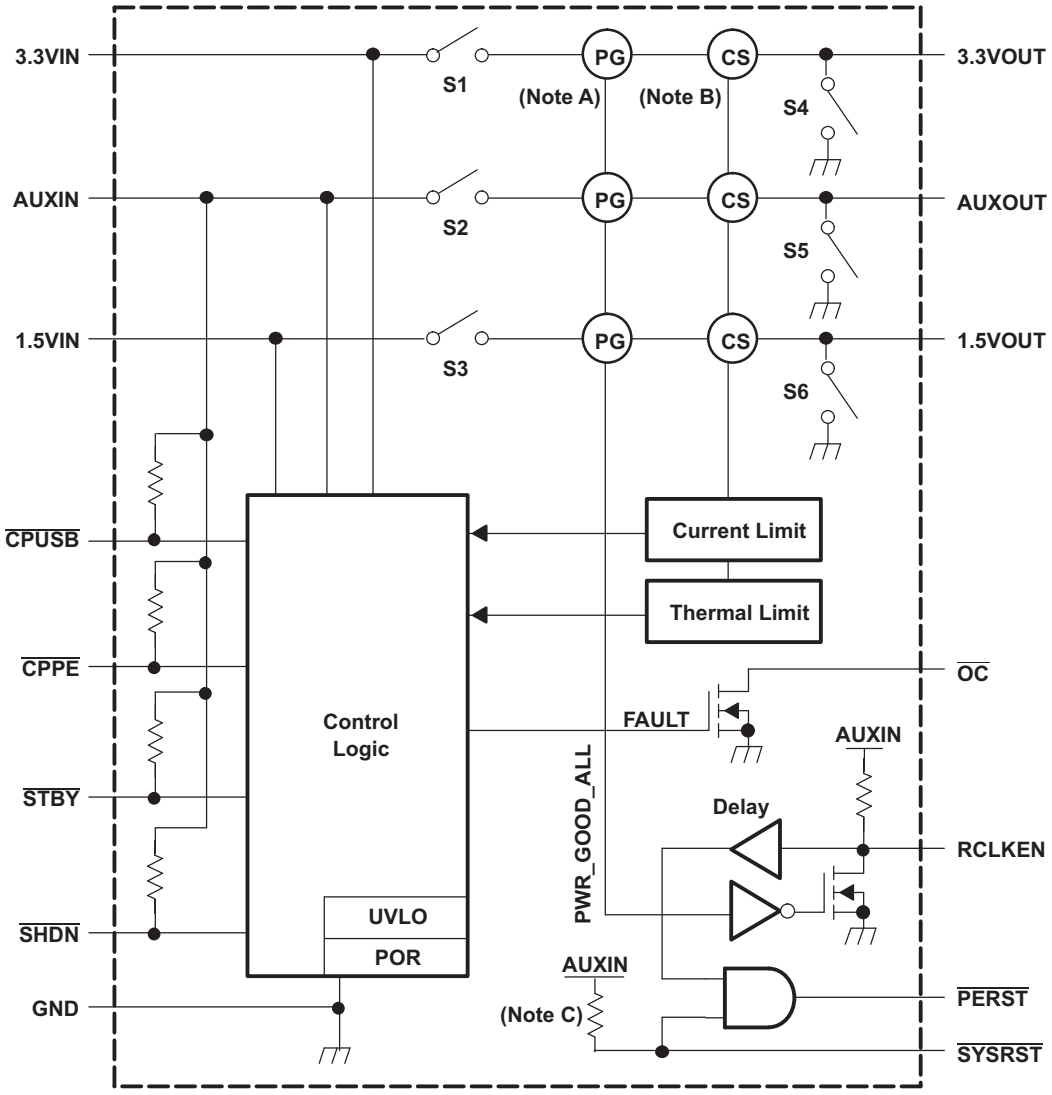

NC - No internal connection

## TERMINAL FUNCTIONS

| TERMINAL | | | | | | I/O | DESCRIPTION |
|---|---|---|---|---|---|---|---|
| TPS2231 | | | | TPS2236 | | | |
| NAME | NO. | | | NAME | NO. | | |
| | PW | PWP | RGP | | DAP | | |
| 3.3VIN | 4, 5 | 5, 6 | 2 | 3.3VIN | 8, 9 | I | 3.3-V input for 3.3VOUT |
| 1.5VIN | 15, 16 | 18, 19 | 12 | 1.5VIN | 24, 25 | I | 1.5-V input for 1.5VOUT |
| AUXIN | 18 | 21 | 17 | AUXIN | 15 | I | AUX input for AUXOUT and chip power |
| GND | 10 | 11 | 7 | GND | 21 | | Ground |
| 3.3VOUT | 6, 7 | 7, 8 | 3 | 3.3VOUT1 | 7 | O | Switched output that delivers 0 V, 3.3 V or high impedance to card |
| 1.5VOUT | 13, 14 | 16, 17 | 11 | 1.5VOUT1 | 26 | O | Switched output that delivers 0 V, 1.5 V or high impedance to card |
| AUXOUT | 17 | 20 | 15 | AUXOUT1 | 14 | O | Switched output that delivers 0 V, AUX or high impedance to card |
| | | | | 3.3VOUT2 | 10 | O | Switched output that delivers 0 V, 3.3 V or high impedance to card |
| | | | | 1.5VOUT2 | 23 | O | Switched output that delivers 0 V, 1.5 V or high impedance to card |
| | | | | AUXOUT2 | 16 | O | Switched output that delivers 0 V, AUX or high impedance to card |
| $\overline{\text{SYSRST}}$ | 1 | 2 | 6 | $\overline{\text{SYSRST}}$ | 30 | I | System Reset input – active low, logic level signal. Internally pulled up to AUXIN. |
| $\overline{\text{CPPE}}$ | 12 | 15 | 10 | $\overline{\text{CPPE1}}$ | 1 | I | Card Present input for PCI Express cards. Internally pulled up to AUXIN |
| $\overline{\text{CPUSB}}$ | 11 | 14 | 9 | $\overline{\text{CPUSB1}}$ | 3 | I | Card Present input for USB cards. Internally pulled up to AUXIN. |
| | | | | $\overline{\text{CPPE2}}$ | 2 | I | Card Present input for PCI Express cards. Internally pulled up to AUXIN. |
| | | | | $\overline{\text{CPUSB2}}$ | 6 | I | Card Present input for USB cards. Internally pulled up to AUXIN. |
| $\overline{\text{PERST}}$ | 8 | 9 | 8 | $\overline{\text{PERST1}}$ | 13 | O | A logic level power good to slot 0 (with delay) |
| | | | | $\overline{\text{PERST2}}$ | 11 | O | A logic level power good to slot 1 (with delay) |
| $\overline{\text{SHDN}}$ | 2 | 3 | 20 | $\overline{\text{SHDN1}}$ | 17 | I | Shutdown input – active low, logic level signal. Internally pulled up to AUXIN. |
| | | | | $\overline{\text{SHDN2}}$ | 18 | I | Shutdown input – active low, logic level signal. Internally pulled up to AUXIN. |
| $\overline{\text{STBY}}$ | 3 | 4 | 1 | $\overline{\text{STBY1}}$ | 28 | I | Standby input – active low, logic level signal. Internally pulled up to AUXIN. |
| | | | | $\overline{\text{STBY2}}$ | 27 | I | Standby input – active low, logic level signal. Internally pulled up to AUXIN. |
| RCLKEN | 19 | 22 | 18 | RCLKEN1 | 32 | I/O | Reference Clock Enable signal. As an output, a logic level power good to host for slot 0 (no delay – open drain). As an input, if kept inactive (low) by the host, prevents $\overline{\text{PERST}}$ from being de-asserted. Internally pulled up to AUXIN. |
| | | | | RCLKEN2 | 31 | I/O | Reference Clock Enable signal. As an output, a logic level power good to host for slot 1 (no delay – open drain). As an input, if kept inactive (low) by the host, prevents $\overline{\text{PERST}}$ from being de-asserted. Internally pulled up to AUXIN. |
| $\overline{\text{OC}}$ | 20 | 23 | 19 | $\overline{\text{OC1}}$ | 19 | O | Overcurrent status output for slot 0 (open drain) |
| | | | | $\overline{\text{OC2}}$ | 20 | O | Overcurrent status output for slot 1 (open drain) |
| NC | 9 | 1, 10, 12, 13, 24 | 4, 5, 13, 14, 16 | NC | 4, 5, 12, 22, 29 | | No connection |

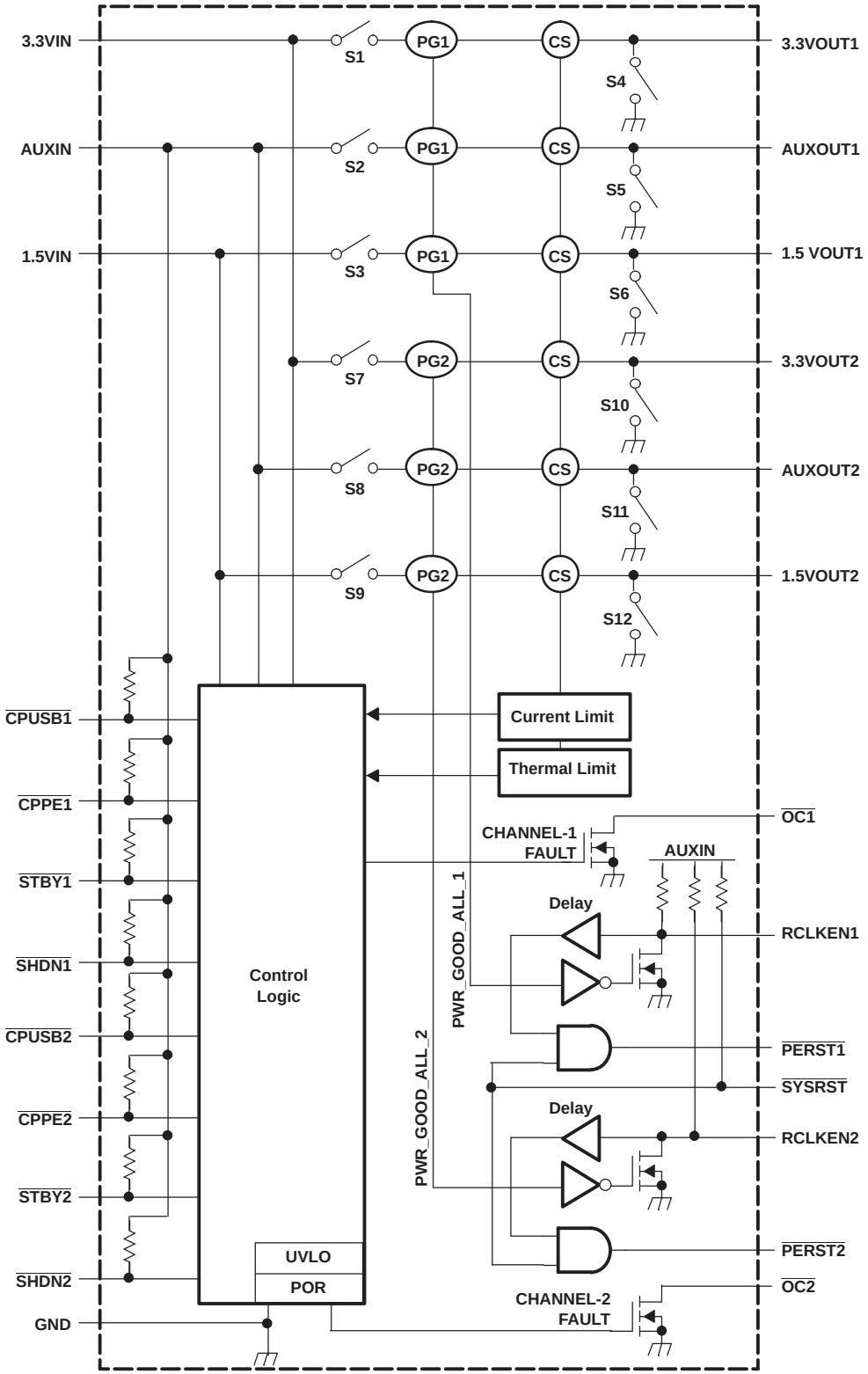
## FUNCTIONAL BLOCK DIAGRAM

### Single ExpressCard Power Switch




Note A: PG = power good
Note B: CS = current sense
Note C: TPS2231MRGP-2 does not have a pull-up resistor.

## Dual ExpressCard Power Switch



## DETAILED PIN DESCRIPTIONS

### $\overline{\text{CPPE}}$

A logic low level on this input indicates that the card present supports PCI Express functions. $\overline{\text{CPPE}}$ connects to the AUXIN input through an internal pullup. When a card is inserted, $\overline{\text{CPPE}}$ is physically connected to ground if the card supports PCI Express functions.

### $\overline{\text{CPUSB}}$

A logic low level on this input indicates that the card present supports USB functions. $\overline{\text{CPUSB}}$ connects to the AUXIN input through an internal pullup. When a card is inserted, $\overline{\text{CPUSB}}$ is physically connected to ground if the card supports USB functions.

### $\overline{\text{SHDN}}$

When asserted (logic low), this input instructs the power switch to turn off all voltage outputs and the discharge FETs are activated. $\overline{\text{SHDN}}$ has an internal pullup connected to AUXIN.

### $\overline{\text{STBY}}$

When asserted (logic low) after the card is inserted, this input places the power switch in standby mode by turning off the 3.3-V and 1.5-V power switches and keeping the AUX switch on. If asserted prior to the card being present, $\overline{\text{STBY}}$ places the power switch in OFF Mode by turning off the AUX, 3.3-V, and 1.5-V power switches. $\overline{\text{STBY}}$ has an internal pullup connected to AUXIN.

### RCLKEN

This pin serves as both an input and an output. On power up, a discharge FET keeps this signal at a low state as long as any of the output power rails are out of their tolerance range. Once all output power rails are within tolerance, the switch releases RCLKEN allowing it to transition to a high state (internally pulled up to AUXIN). The transition of RCLKEN from a low to a high state starts an internal timer for the purpose of deasserting $\overline{\text{PERST}}$. As an input, RCLKEN can be kept low to delay the start of the $\overline{\text{PERST}}$ internal timer.

Because RCLKEN is internally connected to a discharge FET, this pin can only be driven low and should never be driven high as a logic input. When an external circuit drives this pin low, RCLKEN becomes an input; otherwise, this pin is an output.

RCLKEN can be used by the host system to enable a clock driver.

### $\overline{\text{PERST}}$

On power up, this output remains asserted (logic level low) until all power rails are within tolerance. Once all power rails are within tolerance and RCLKEN has been released (logic high), $\overline{\text{PERST}}$ is deasserted (logic high) after a time delay as shown in the parametric table. On power down, this output is asserted whenever any of the power rails drop below their voltage tolerance.

The $\overline{\text{PERST}}$ signal is an output from the host system and an input to the ExpressCard module. This signal is only used by PCI Express-based modules and its function is to place the ExpressCard module in a reset state.

During power up, power down, or whenever power to the ExpressCard module is not stable or not within voltage tolerance limits, the ExpressCard standard requires that $\overline{\text{PERST}}$ be asserted. As a result, this signal also serves as a power-good indicator to the ExpressCard module, and the relationship between the power rails and $\overline{\text{PERST}}$ are explicitly defined in the ExpressCard standard.

The host can also place the ExpressCard module in a reset state by asserting a system reset $\overline{\text{SYSRST}}$. This system reset generates a $\overline{\text{PERST}}$ to the ExpressCard module without disrupting the voltage rails. This is what is normally called a *warm* reset. However, in a *cold* start situation, the system reset can also be used to extend the length of time that $\overline{\text{PERST}}$ is asserted.

### $\overline{\text{SYSRST}}$

This input is driven by the host system and directly affects $\overline{\text{PERST}}$. Asserting $\overline{\text{SYSRST}}$ (logic low) forces $\overline{\text{PERST}}$ to assert. RCLKEN is not affected by the assertion of $\overline{\text{SYSRST}}$. $\overline{\text{SYSRST}}$ has an internal pullup connected to AUXIN.

### $\overline{\text{OC}}$

This pin is an open-drain output. When any of the three power switches (AUX, 3.3V, and 1.5V) is in an overcurrent condition, $\overline{\text{OC}}$ is asserted (logic low) by an internal discharge FET with a deglitch delay. Otherwise, the discharge FET is open, and the pin can be pulled up to a power supply through an external resistor.

## FUNCTIONAL TRUTH TABLES

### Truth Table for Voltage Outputs

| VOLTAGE INPUTS(1) | | | LOGIC INPUTS | | | VOLTAGE OUTPUTS(2) | | | MODE(3) |
|---|---|---|---|---|---|---|---|---|---|
| AUXIN | 3.3VIN | 1.5VIN | $\overline{\text{SHDN}}$ | $\overline{\text{STBY}}$ | $\overline{\text{CP}}$ (4) | AUXOUT | 3.3VOUT | 1.5VOUT | |
| Off | x | x | x | x | x | Off | Off | Off | OFF |
| On | x | x | 0 | x | x | GND | GND | GND | Shutdown |
| On | x | x | 1 | x | 1 | GND | GND | GND | No Card |
| On | On | On | 1 | 0 | 0 | On | Off | Off | Standby |
| On | On | On | 1 | 1 | 0 | On | On | On | Card Inserted |

(1) For input voltages, *On* means the respective input voltage is higher than its turnon threshold voltage; otherwise, the voltage is *Off* (for AUX input,*Off* means the voltage is close to zero volt).
(2) For output voltages, *On* means the respective power switch is turned on so the input voltage is connected to the output; *Off* means the power switch and its output discharge FET are both off; *GND* means the power switch is off but the output discharge FET is on so the voltage on the output is pulled down to 0 V.
(3) *Mode* assigns each set of input conditions and respective output voltage results to a different name. These modes are referred to as input conditions in the following *Truth Table for Logic Outputs*.
(4) $\overline{\text{CP}}$ = $\overline{\text{CPUSB}}$ and $\overline{\text{CPPE}}$ – equal to 1 when both $\overline{\text{CPUSB}}$ and $\overline{\text{CPPE}}$ signals are logic high, or equal to 0 when either $\overline{\text{CPUSB}}$ or $\overline{\text{CPPE}}$ is low.

### Truth Table for Logic Outputs

| INPUT CONDITIONS | | | LOGIC OUTPUTS | |
|---|---|---|---|---|
| MODE | $\overline{\text{SYSRST}}$ | RCLKEN(1) | $\overline{\text{PERST}}$ | RCLKEN(2) |
| OFF | X | X | 0 | 0 |
| Shutdown | | | | |
| No Card | | | | |
| Standby | | | | |
| Card Inserted | 0 | Hi-Z | 0 | 1 |
| | 0 | 0 | 0 | 0 |
| | 1 | Hi-Z | 1 | 1 |
| | 1 | 0 | 0 | 0 |

(1) RCLKEN as a logic input in this column. RCLKEN is an I/O pin and it can be driven low externally, left open, or connected to high-impedance terminals, such as the gate of a MOSFET. It must not be driven high externally.
(2) RCLKEN as a logic output in this column.

## POWER STATES

If AUXIN is not present, then all input-to-output power switches are kept off (*OFF* mode).

If AUXIN is present and $\overline{\text{SHDN}}$ is asserted (logic low), then all input-to-output power switches are kept off and the output discharge FETs are turned on (*Shutdown* mode). If $\overline{\text{SHDN}}$ is asserted and then de-asserted, the state on the outputs is restored to the state prior to $\overline{\text{SHDN}}$ assertion.

If 3.3VIN, AUXIN and 1.5VIN are present at the input of the power switch and no card is inserted, then all input-to-output power switches are kept off and the output discharge FETs are turned on (*No Card* mode).

If 3.3VIN, AUXIN and 1.5VIN are present at the input of the power switch prior to a card being inserted, then all input-to-output power switches are turned on once a card-present signal ($\overline{\text{CPUSB}}$ and/or $\overline{\text{CPPE}}$) is detected (*Card Inserted* mode).

If a card is present and all output voltages are being applied, then the $\overline{\text{STBY}}$ is asserted (logic low); the AUXOUT voltage is provided to the card, and the 3.3VOUT and 1.5VOUT switches are turned off (*Standby* mode).

If a card is present and all output voltages are being applied, then the 1.5VIN, or 3.3VIN is removed from the input of the power switch; the AUXOUT voltage is provided to the card and the 3.3VOUT and 1.5VOUT switches are turned off (*Standby* mode).

If prior to the insertion of a card, the AUXIN is available at the input of the power switch and 3.3VIN and/or 1.5VIN are not, or if $\overline{\text{STBY}}$ is asserted (logic low), then no power is made available to the card (*OFF* mode). If 1.5VIN and 3.3VIN are made available at the input of the power switch after the card is inserted and $\overline{\text{STBY}}$ is not asserted, all the output voltages are made available to the card (*Card Inserted* mode).

## DISCHARGE FETs

The discharge FETs on the outputs are activated whenever the device detects that a card is not present (*No Card* mode). Activation occurs after the input-to-output power switches are turned off (break before make). The discharge FETs de-activate if either of the card-present lines go active low, unless the $\overline{\text{SHDN}}$ pin is asserted.

The discharge FETs are also activated whenever the $\overline{\text{SHDN}}$ input is asserted and stay asserted until $\overline{\text{SHDN}}$ is de-asserted.

## PARAMETER MEASUREMENT INFORMATION

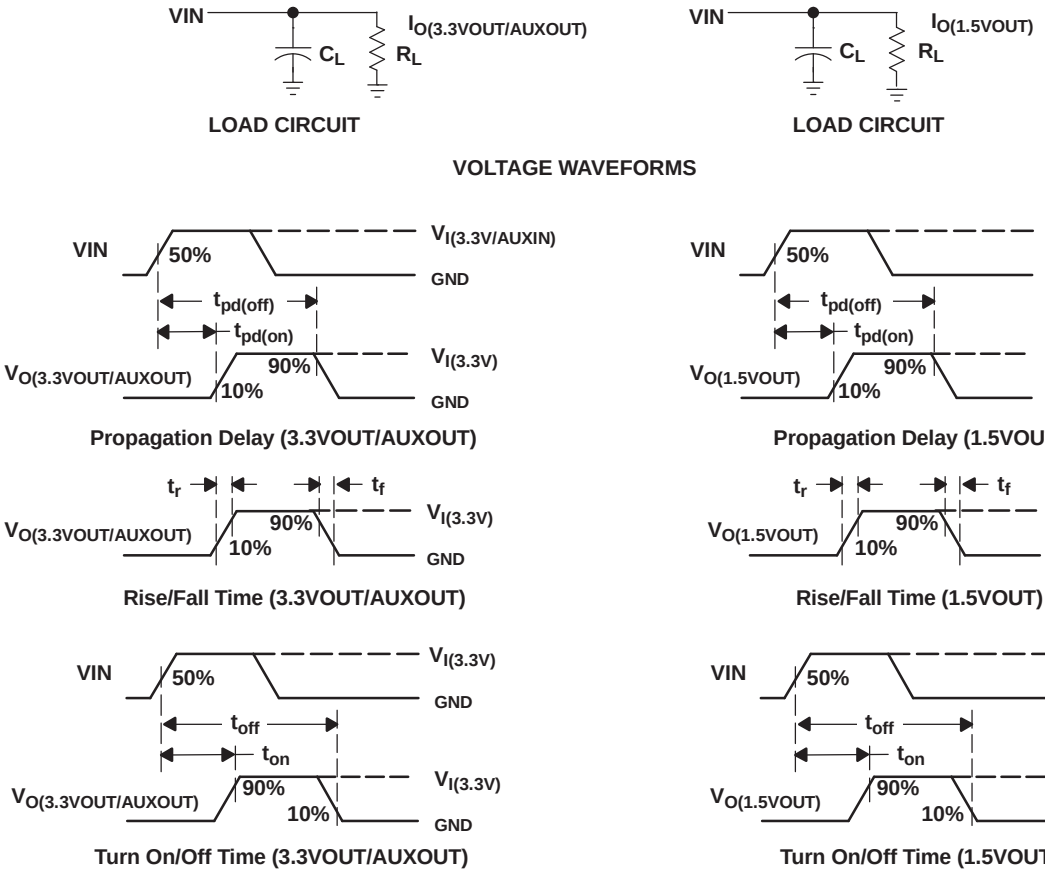



**Figure 1. Test Circuits and Voltage Waveforms**

## TYPICAL CHARACTERISTICS

### Table of Graphs

| | | FIGURE |
|---|---|---|
| Output voltage when card is inserted | vs Time | 2 |
| RCLKEN and $\overline{\text{PERST}}$ voltage during power up | vs Time | 3 |
| RCLKEN and $\overline{\text{PERST}}$ voltage during power down | vs Time | 4 |
| $\overline{\text{PERST}}$ asserted by $\overline{\text{SYSRST}}$ when power is on | vs Time | 5 |
| $\overline{\text{PERST}}$ de-asserted by $\overline{\text{SYSRST}}$ when power is on | vs Time | 6 |
| Output voltage when 3.3VIN is removed | vs Time | 7 |
| Output voltage when 1.5VIN is removed | vs Time | 8 |
| $\overline{\text{OC}}$ response when powered into a short (3.3VOUT) | vs Time | 9 |
| Supply current of AUXIN | vs Junction temperature | 10 |
| Static drain-source on-state resistance | vs Junction temperature | 11 |
| 3.3-V power switch current limit | vs Junction temperature | 12 |
| 1.5-V power switch current limit | vs Junction temperature | 13 |
| AUX power switch current limit | vs Junction temperature | 14 |
| 3.3-V power switch current limit trip | vs Junction temperature | 15 |
| 1.5-V power switch current limit trip | vs Junction temperature | 16 |
| AUX power switch current limit trip | vs Junction temperature | 17 |

**OUTPUT VOLTAGE WHEN CARD IS INSERTED vs TIME**

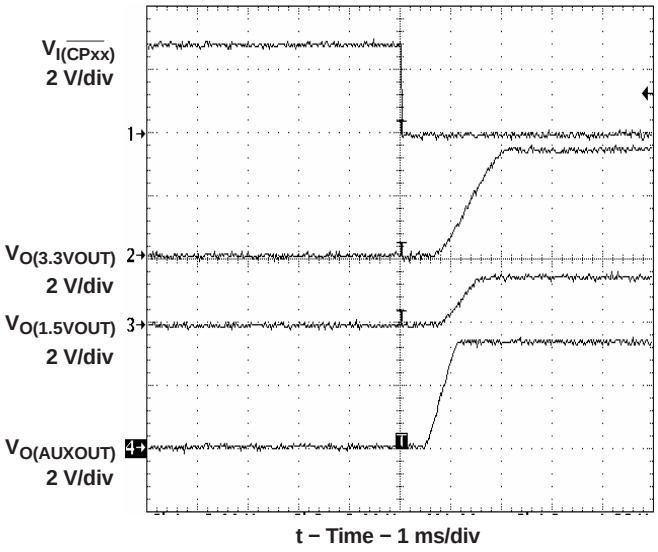



**Figure 2.**

**RCLKEN AND $\overline{PERST}$ VOLTAGE DURING POWER UP vs TIME**

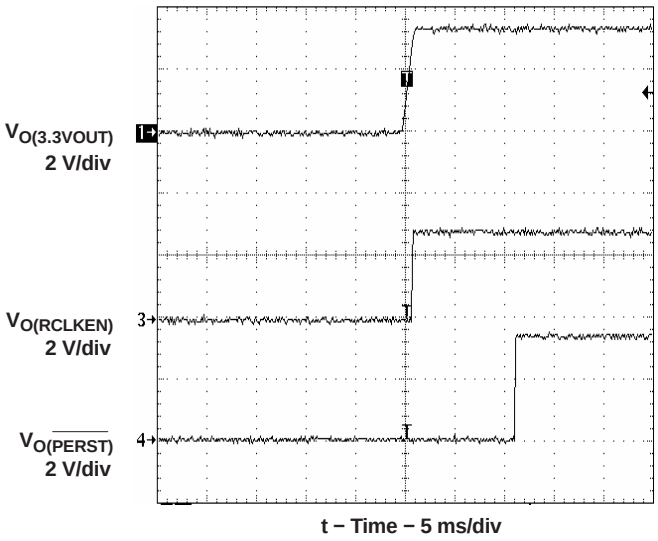



**Figure 3.**

**RCLKEN AND $\overline{PERST}$ VOLTAGE DURING POWER DOWN vs TIME**

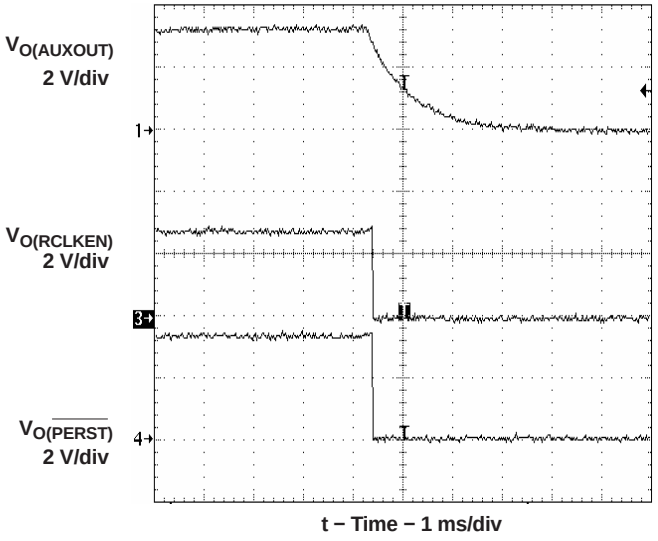



**Figure 4.**

**$\overline{PERST}$ ASSERTED BY $\overline{SYSRST}$ WHEN POWER IS ON vs TIME**

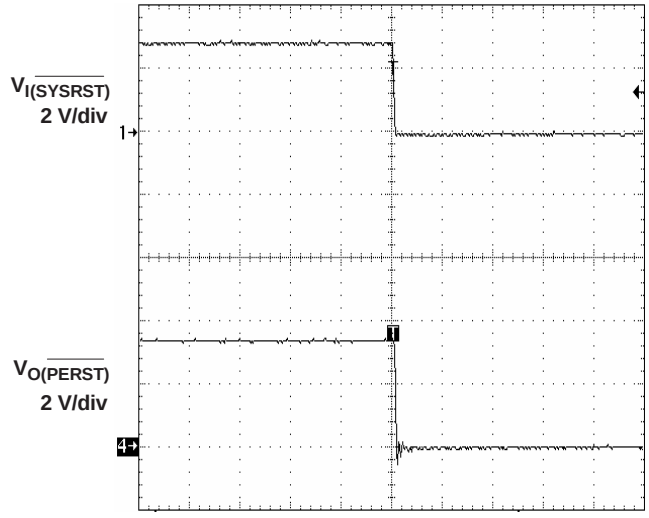



**Figure 5.**

**$\overline{\text{PERST}}$ DE-ASSERTED BY $\overline{\text{SYSRST}}$ WHEN POWER IS ON**
**vs**
**TIME**

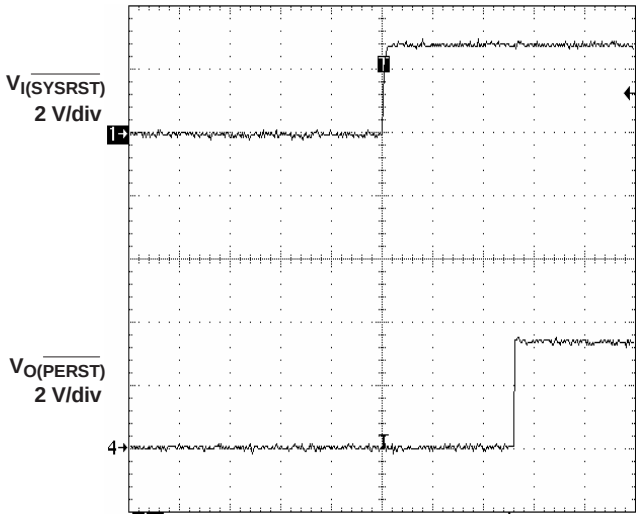



**Figure 6.**

**OUTPUT VOLTAGE WHEN 3.3VIN IS REMOVED**
**vs**
**TIME**

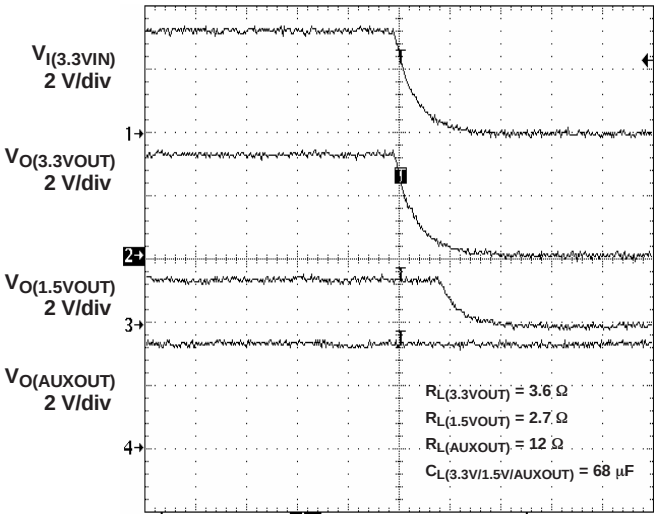



**Figure 7.**

**OUTPUT VOLTAGE WHEN 1.5VIN IS REMOVED**
**vs**
**TIME**

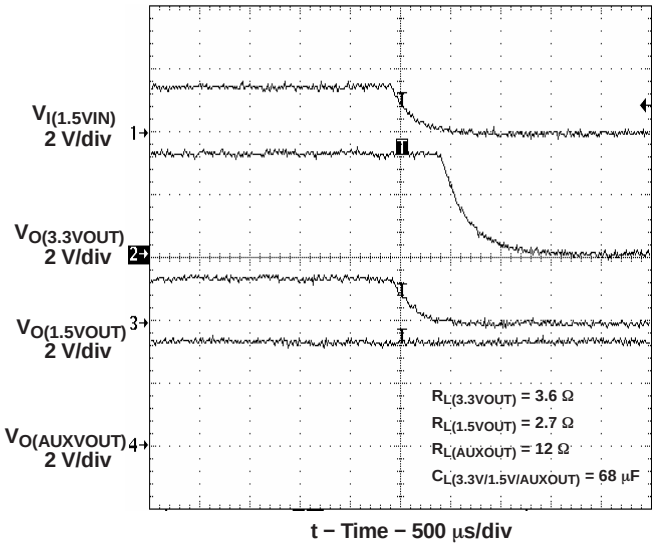



**Figure 8.**

**$\overline{\text{OC}}$ RESPONSE WHEN POWERED INTO A SHORT (3.3VOUT)**
**vs**
**TIME**

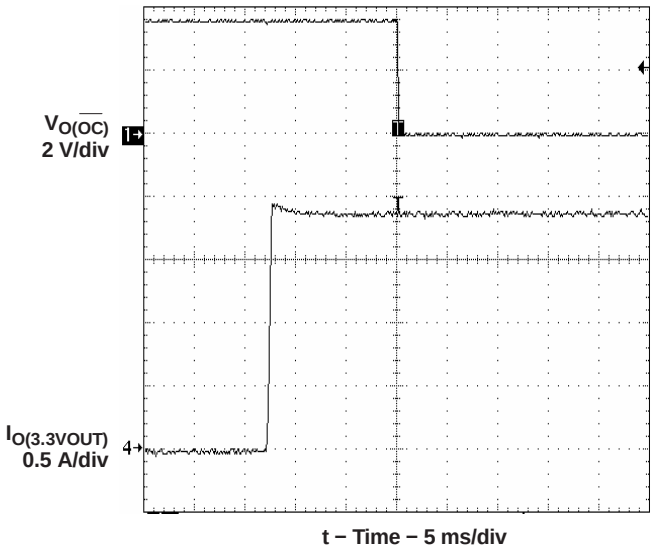



**Figure 9.**

SUPPLY CURRENT OF AUXIN
vs
JUNCTION TEMPERATURE

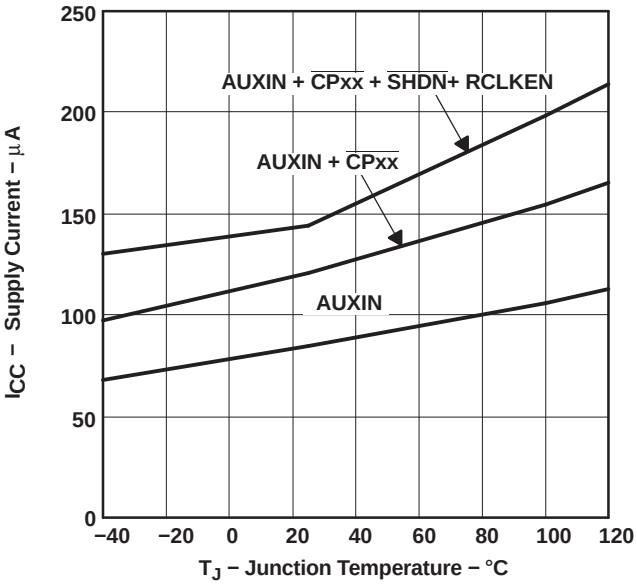



Figure 10.

STATIC DRAIN-SOURCE ON-STATE RESISTANCE
vs
JUNCTION TEMPERATURE

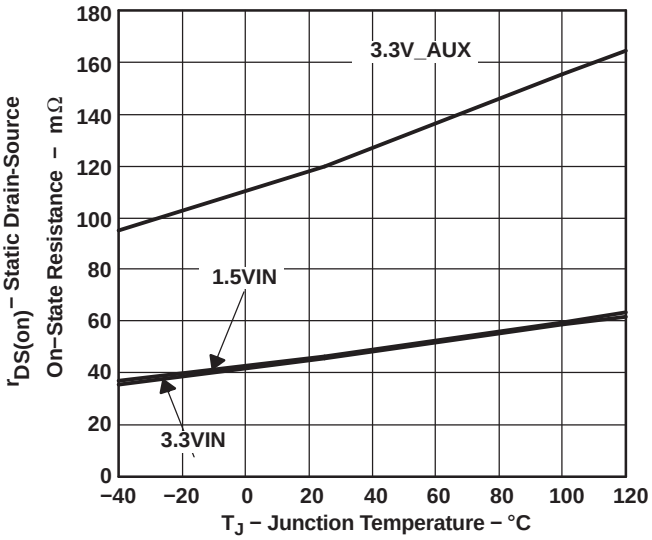



Figure 11.

3.3-V POWER SWITCH CURRENT LIMIT
vs
JUNCTION TEMPERATURE

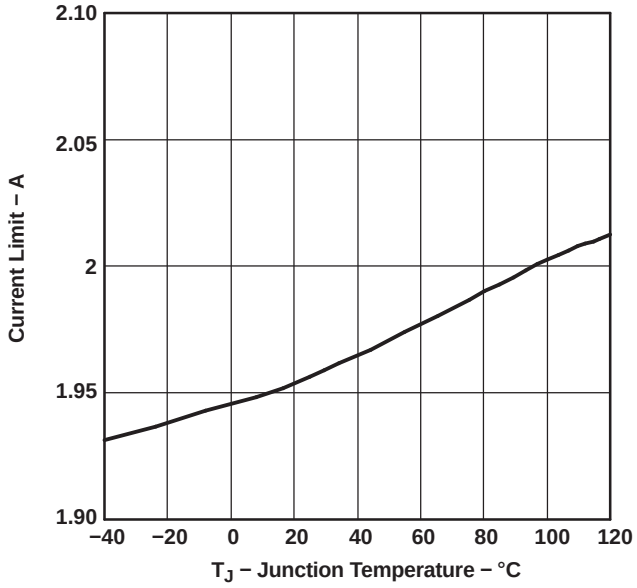



Figure 12.

1.5-V POWER SWITCH CURRENT LIMIT
vs
JUNCTION TEMPERATURE

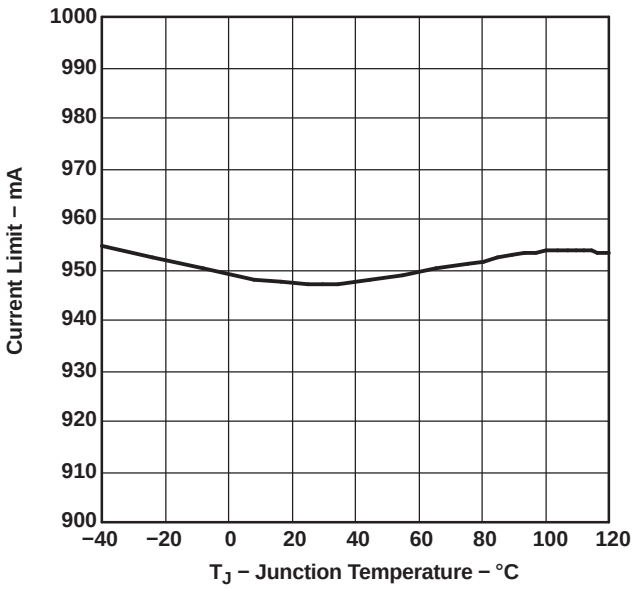



Figure 13.

AUX POWER SWITCH CURRENT LIMIT
vs
JUNCTION TEMPERATURE

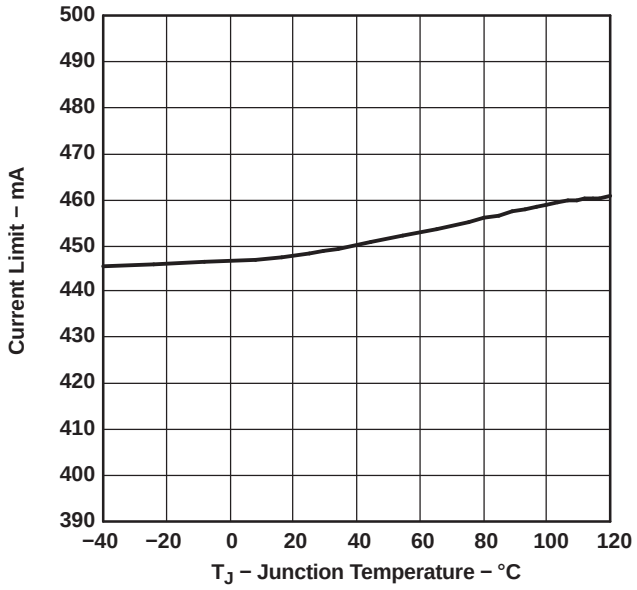



Figure 14.

3.3-V POWER SWITCH CURRENT LIMIT TRIP
vs
JUNCTION TEMPERATURE

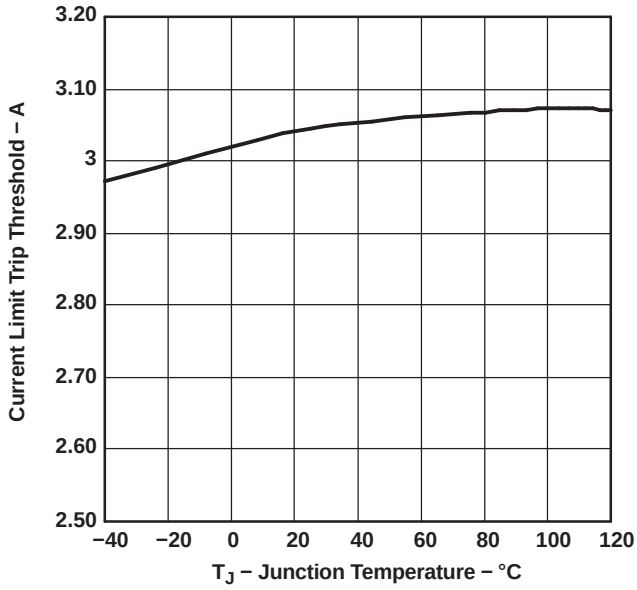



Figure 15.

1.5-V POWER SWITCH CURRENT LIMIT TRIP
vs
JUNCTION TEMPERATURE

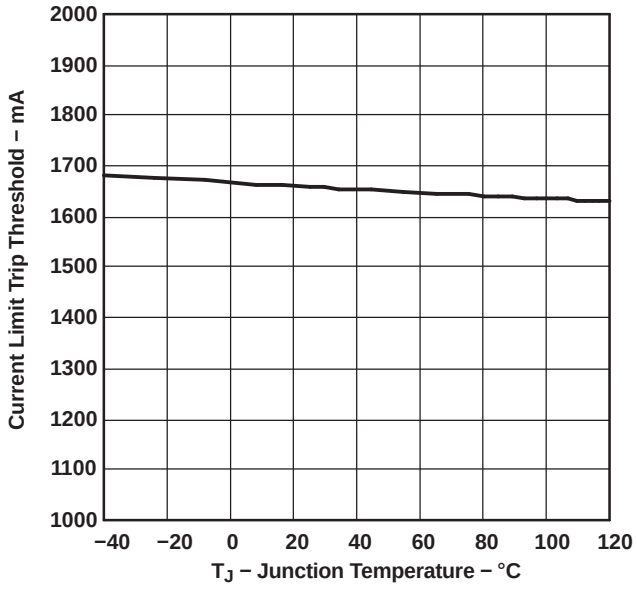



Figure 16.

AUX POWER SWITCH CURRENT LIMIT TRIP
vs
JUNCTION TEMPERATURE

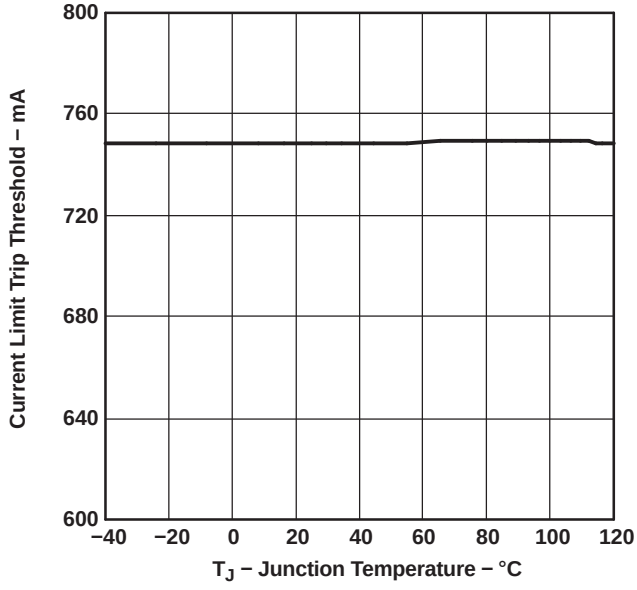



Figure 17.

# APPLICATION INFORMATION

## INTRODUCTION TO ExpressCard

An ExpressCard module is an add-in card with a serial interface based on PCI Express and/or Universal Serial Bus (USB) technologies. An ExpressCard comes in two form factors defined as ExpressCard|34 or ExpressCard|54. The difference, as defined by the name, is the width of the module, 34 mm or 54 mm, respectively. Host systems supporting the ExpressCard module can support either the ExpressCard|34 or ExpressCard|54 or both.

## ExpressCard POWER REQUIREMENTS

Regardless of which ExpressCard module is used, the power requirements as defined in the ExpressCard Standard apply to both on an individual slot basis. The host system is required to supply 3.3 V, 1.5 V, and AUX to each of the ExpressCard slots. However, the voltage is only applied after an ExpressCard is inserted into the slot.

The ExpressCard connector has two pins, $\overline{\text{CPPE}}$ and $\overline{\text{CPUSB}}$, that are used to signal the host when a card is inserted. If the ExpressCard module itself connects the $\overline{\text{CPPE}}$ to ground, the logic low level on that signal indicates to the host that a card supporting PCI Express has been inserted. If $\overline{\text{CPUSB}}$ is connected to ground, then the ExpressCard module supports the USB interface. If both PCI Express and USB are supported by the ExpressCard module, then both signals, $\overline{\text{CPPE}}$ and $\overline{\text{CPUSB}}$, must be connected to ground.

In addition to the Card Present signals ($\overline{\text{CPPE}}$ and $\overline{\text{CPUSB}}$), the host system determines when to apply power to the ExpressCard module based on the state of the system. The state of the system is defined by the state of the 3.3 V, 1.5 V, and AUX input voltage rails. For the sake of simplicity, the 3.3-V and 1.5-V rails are defined as the primary voltage rails as oppose to the auxiliary voltage rail, AUX.

## ExpressCard POWER SWITCH OPERATION

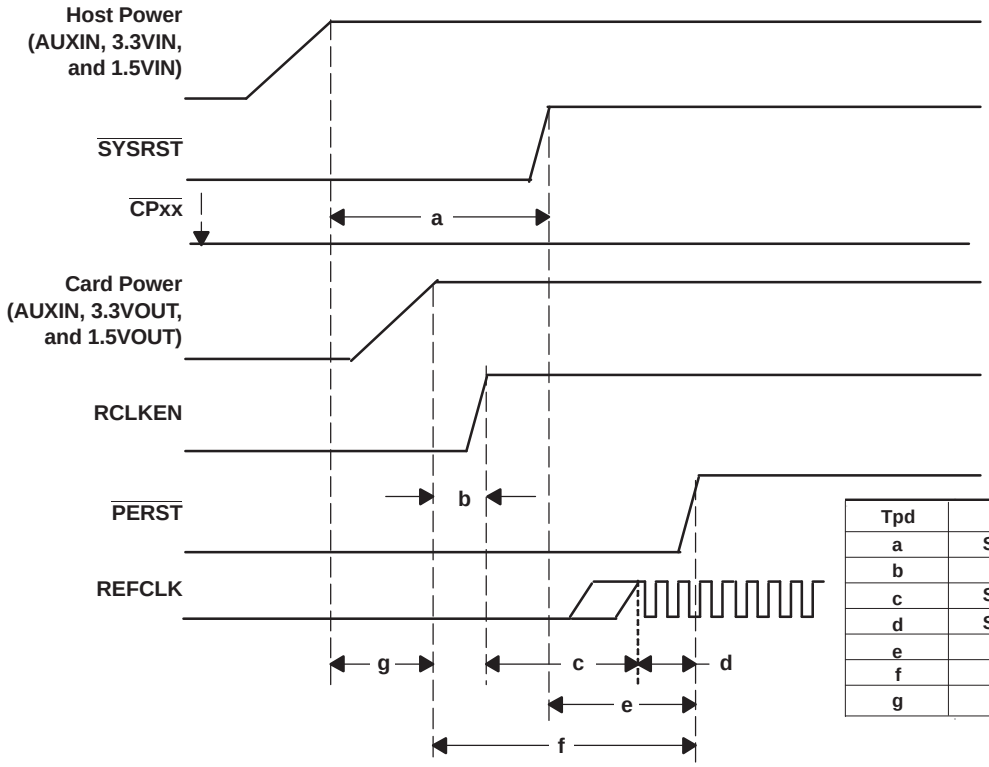
The ExpressCard power switch resides on the host, and its main function is to control when to send power to the ExpressCard slot. The ExpressCard power switch makes decisions based on the Card Present inputs and on the state of the host system as defined by the primary and auxiliary voltage rails.

The following conditions define the operation of the host power controller:

1. When both primary power and auxiliary power at the input of the ExpressCard power switch are off, then all power to the ExpressCard connector is off regardless of whether a card is present.
2. When both primary power and auxiliary power at the input of the ExpressCard power switch are on, then power is only applied to the ExpressCard after the ExpressCard power switch detects that a card is present.
3. When primary power (either +3.3 V or +1.5 V) at the input of the ExpressCard power switch is off and auxiliary power at the input of the ExpressCard power switch is on, then the ExpressCard power switch behaves in the following manner:
   a. If neither of the Card Present inputs is detected (no card inserted), then no power is applied to the ExpressCard slot.
   b. If the card is inserted after the system has entered this power state, then no power is applied to the ExpressCard slot.
   c. If the card is inserted prior to the removal of the primary power (either +3.3 V or +1.5 V or both) at the input of the ExpressCard power switch, then only the primary power (both +3.3 V and +1.5 V) is removed and the auxiliary power is sent to the ExpressCard slot.

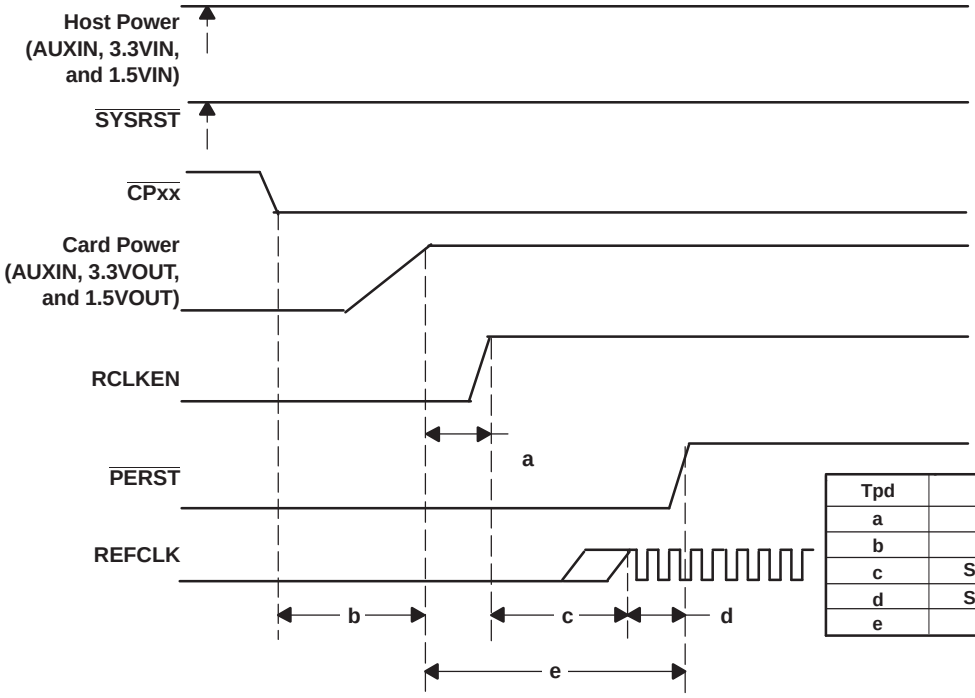
Figure 18 through Figure 23 illustrate the timing relationships between power/logic inputs and outputs of ExpressCard.

## EXPRESS CARD TIMING DIAGRAMS



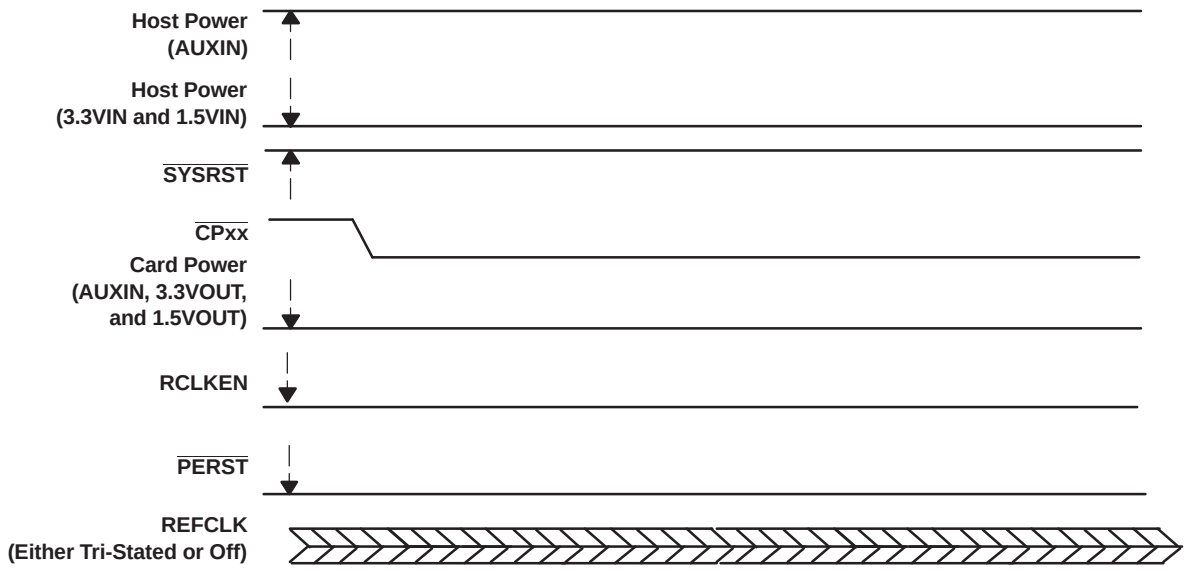

| Tpd | Min | Max | Units |
|---|---|---|---|
| a | System Dependent | | |
| b | | 100 | µS |
| c | System Dependent | | |
| d | System Dependent | | |
| e | 100 | | µS |
| f | 4 | 20 | ms |
| g | | 10 | ms |

**Figure 18. Timing Signals - Card Present Before Host Power Is On**



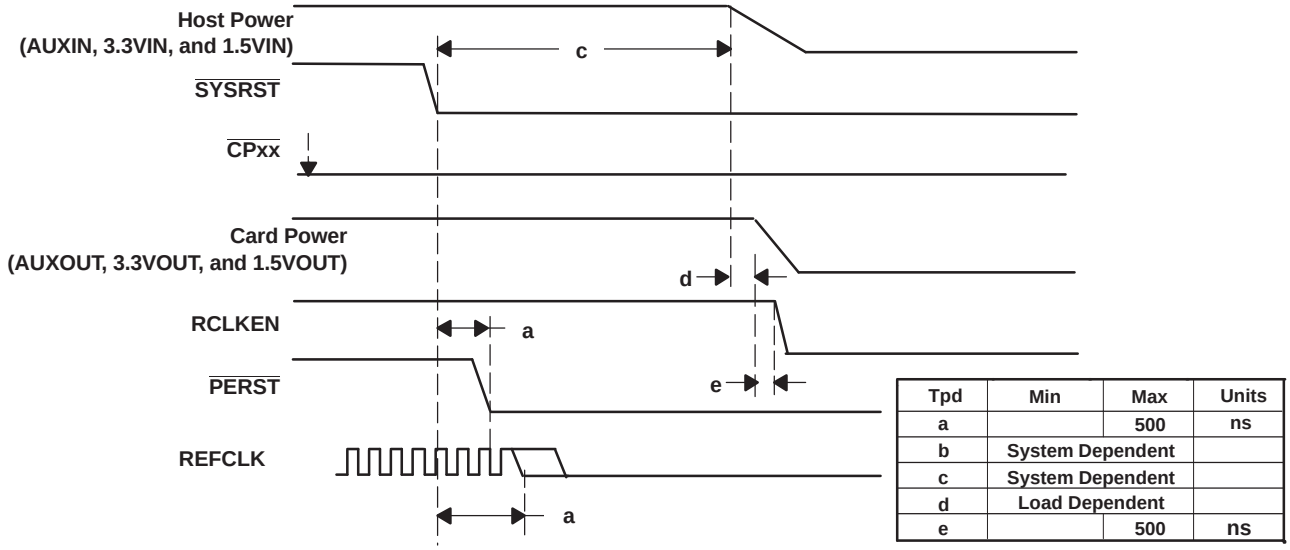

| Tpd | Min | Max | Units |
|---|---|---|---|
| a | | 100 | µS |
| b | | 10 | ms |
| c | System Dependent | | |
| d | System Dependent | | |
| e | 4 | 20 | ms |

**Figure 19. Timing Signals - Host Power Is On Prior to Card Insertion**



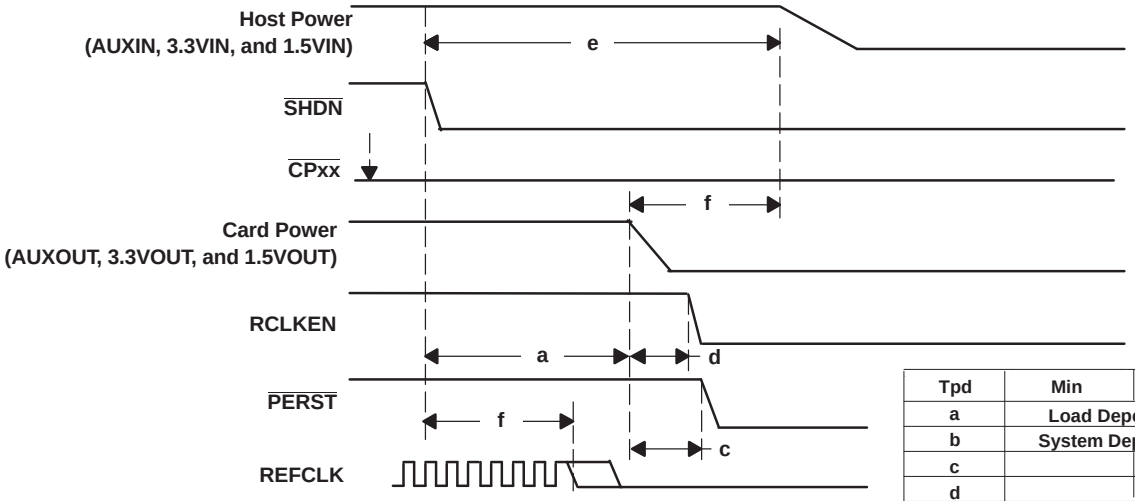

Note: Once 3.3 V and 1.5 V are applied, the power switch follows the power-up sequence of Figure 18 or Figure 19.

**Figure 20. Timing Signals - Host System In Standby Prior to Card Insertion**



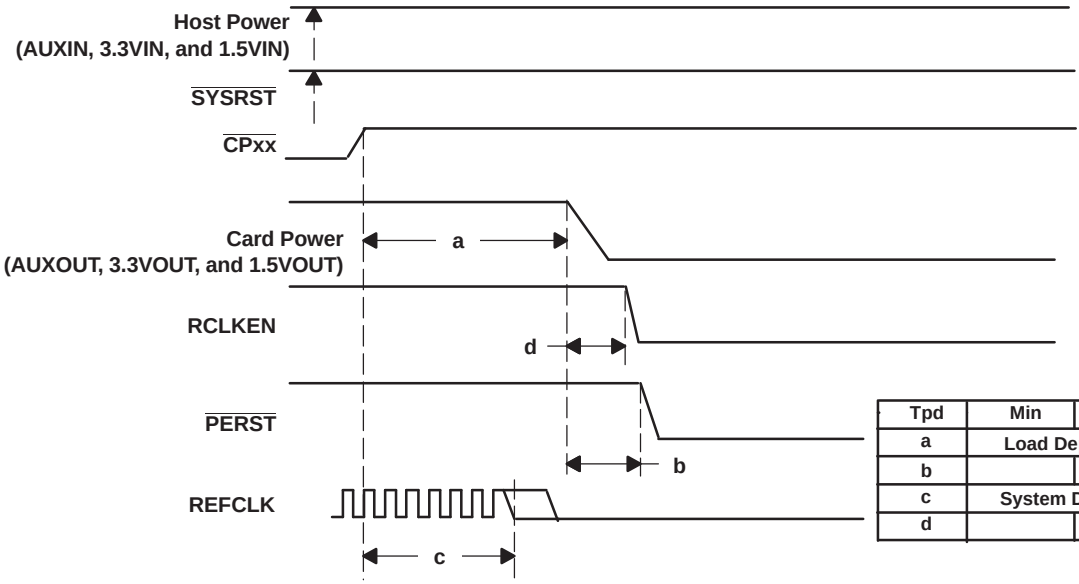

| Tpd | Min | Max | Units |
|---|---|---|---|
| a | | 500 | ns |
| b | System Dependent | | |
| c | System Dependent | | |
| d | Load Dependent | | |
| e | | 500 | ns |

**Figure 21. Timing Signals - Host-Controlled Power Down**




| Tpd | Min | Max | Units |
|---|---|---|---|
| a | Load Dependent | | |
| b | System Dependent | | |
| c | | 500 | ns |
| d | | 500 | ns |
| e | System Dependent | | |
| f | System Dependent | | |

**Figure 22. Timing Signals - Controlled Power Down When $\overline{\text{SHDN}}$ Asserted**

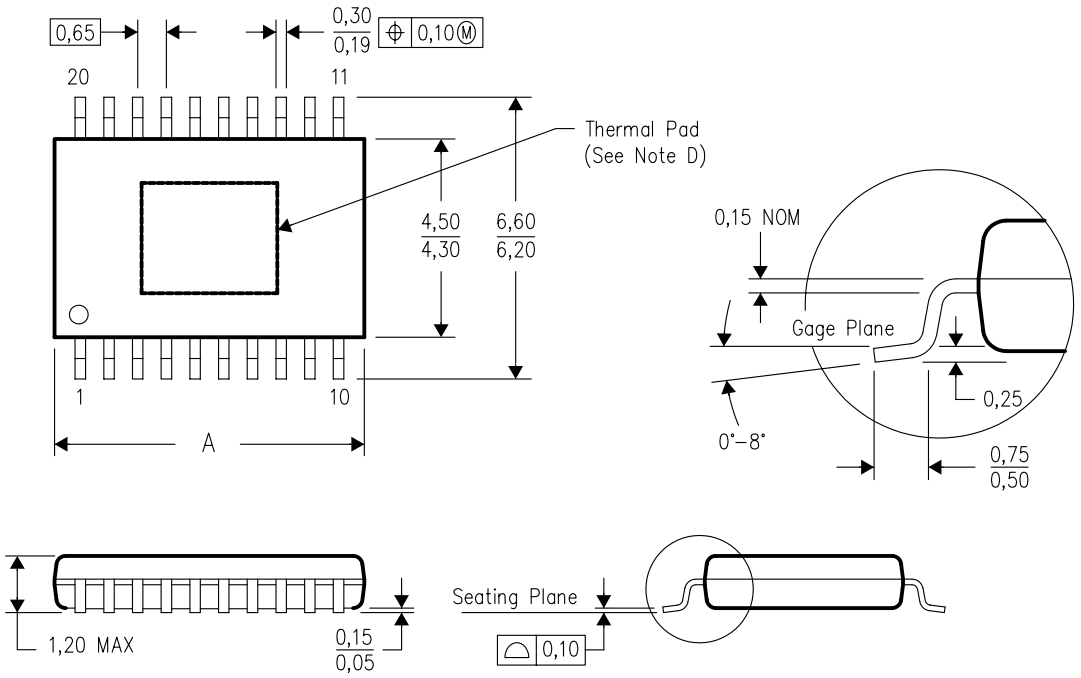



| Tpd | Min | Max | Units |
|---|---|---|---|
| a | Load Dependent | | |
| b | | 500 | ns |
| c | System Dependent | | |
| d | | 500 | ns |

**Figure 23. Timing Signals - Suprise Card Removal**

## PWP (R–PDSO–G**) PowerPAD™ PLASTIC SMALL–OUTLINE PACKAGE

20 PIN SHOWN




| DIM \ PINS ** | 14 | 16 | 20 | 24 | 28 |
|---|---|---|---|---|---|
| A MAX | 5,10 | 5,10 | 6,60 | 7,90 | 9,80 |
| A MIN | 4,90 | 4,90 | 6,40 | 7,70 | 9,60 |

4073225/H 12/05

NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusions. Mold flash and protrusion shall not exceed 0.15 per side.
D. This package is designed to be soldered to a thermal pad on the board. Refer to Technical Brief, PowerPad Thermally Enhanced Package, Texas Instruments Literature No. SLMA002 for information regarding recommended board layout. This document is available at www.ti.com <http://www.ti.com>.
E. Falls within JEDEC MO–153

**PowerPAD is a trademark of Texas Instruments.**

# THERMAL PAD MECHANICAL DATA

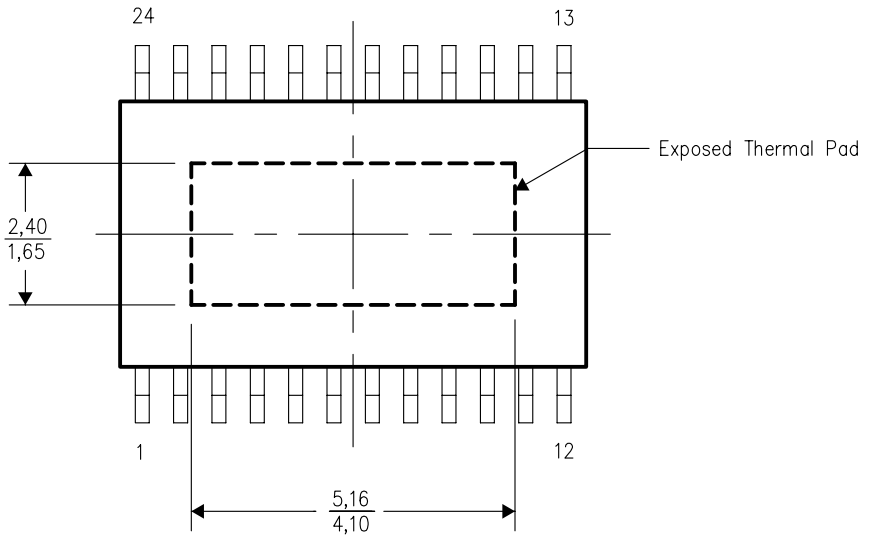
## PWP (R–PDSO–G24)

### THERMAL INFORMATION

This PowerPAD™ package incorporates an exposed thermal pad that is designed to be attached directly to an external heatsink. The thermal pad must be soldered directly to the printed circuit board (PCB). After soldering, the PCB can be used as a heatsink. In addition, through the use of thermal vias, the thermal pad can be attached directly to the appropriate copper plane shown in the electrical schematic for the device, or alternatively, can be attached to a special heatsink structure designed into the PCB. This design optimizes the heat transfer from the integrated circuit (IC).

For additional information on the PowerPAD package and how to take advantage of its heat dissipating abilities, refer to Technical Brief, PowerPAD Thermally Enhanced Package, Texas Instruments Literature No. SLMA002 and Application Brief, PowerPAD Made Easy, Texas Instruments Literature No. SLMA004. Both documents are available at www.ti.com.

The exposed thermal pad dimensions for this package are shown in the following illustration.

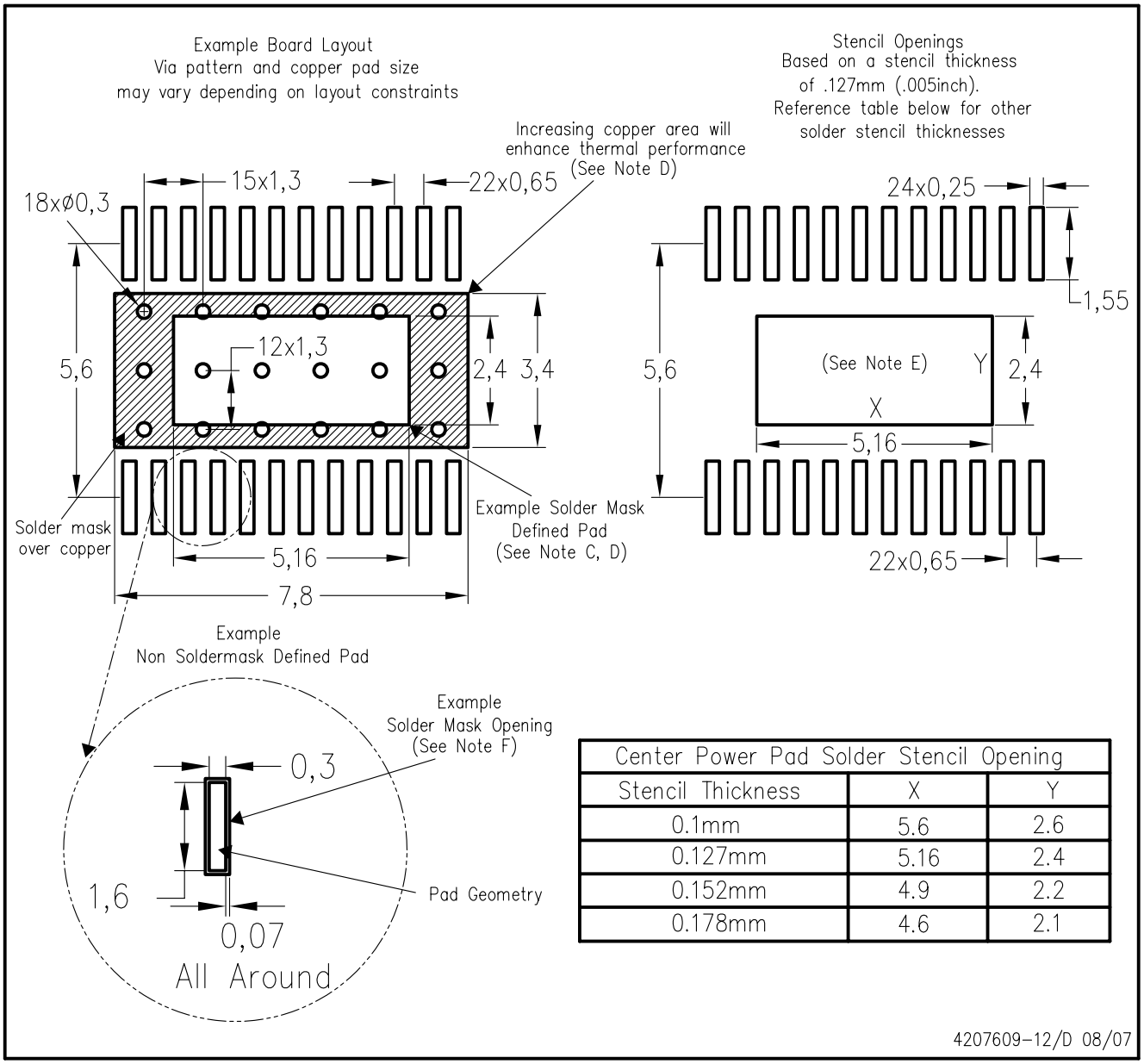



Top View

NOTE: All linear dimensions are in millimeters

Exposed Thermal Pad Dimensions

# PWP (R–PDSO–G24) PowerPAD™




| Center Power Pad Solder Stencil Opening | | |
|---|---|---|
| Stencil Thickness | X | Y |
| 0.1mm | 5.6 | 2.6 |
| 0.127mm | 5.16 | 2.4 |
| 0.152mm | 4.9 | 2.2 |
| 0.178mm | 4.6 | 2.1 |

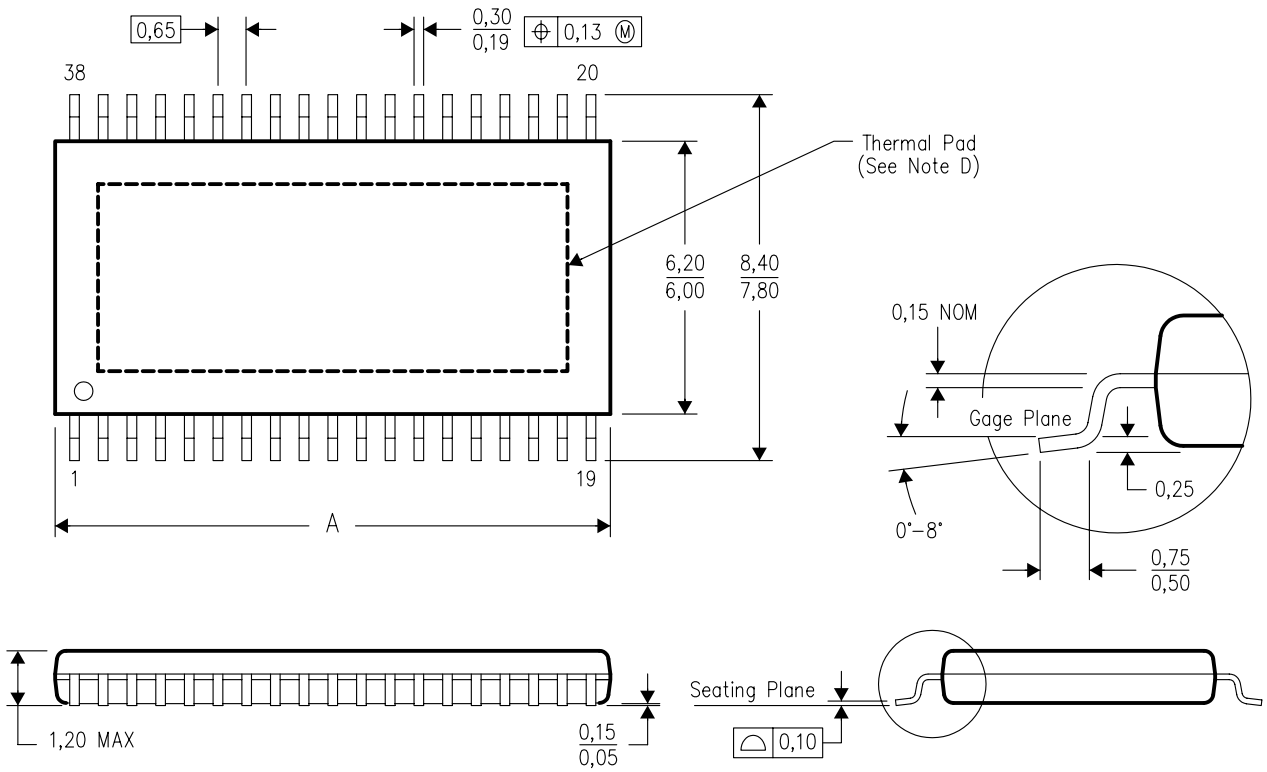
4207609–12/D 08/07

NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Customers should place a note on the circuit board fabrication drawing not to alter the center solder mask defined pad.
D. This package is designed to be soldered to a thermal pad on the board. Refer to Technical Brief, PowerPad Thermally Enhanced Package, Texas Instruments Literature No. SLMA002, SLMA004, and also the Product Data Sheets for specific thermal information, via requirements, and recommended board layout. These documents are available at www.ti.com <http://www.ti.com>. Publication IPC–7351 is recommended for alternate designs.
E. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Example stencil design based on a 50% volumetric metal load solder paste. Refer to IPC–7525 for other stencil recommendations.
F. Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

PowerPAD is a trademark of Texas Instruments.

# DAP (R–PDSO–G**) PowerPAD™ PLASTIC SMALL–OUTLINE PACKAGE

38 PINS SHOWN




| DIM \ PINS ** | 28 | 30 | 32 | 38 |
|---|---|---|---|---|
| A MAX | 9,80 | 11,10 | 11,10 | 12,60 |
| A MIN | 9,60 | 10,90 | 10,90 | 12,40 |

4073257/C 11/05

NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion. Mold flash and protrusion shall not exceed 0.15 per side.
D. This package is designed to be soldered to a thermal pad on the board. Refer to Technical Brief, PowerPad Thermally Enhanced Package, Texas Instruments Literature No. SLMA002 for information regarding recommended board layout. This document is available at www.ti.com <http://www.ti.com>.
E. Falls within JEDEC MO–153

**PowerPAD is a trademark of Texas Instruments.**

# THERMAL PAD MECHANICAL DATA

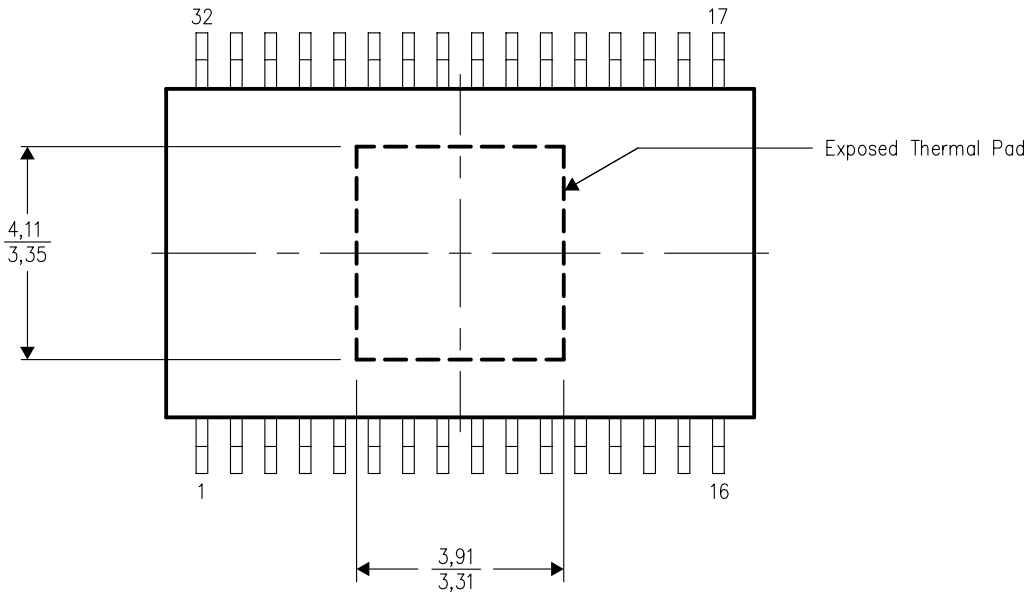
## DAP (R–PDSO–G32)

### THERMAL INFORMATION

This PowerPAD™ package incorporates an exposed thermal pad that is designed to be attached directly to an external heatsink. When the thermal pad is soldered directly to the printed circuit board (PCB), the PCB can be used as a heatsink. In addition, through the use of thermal vias, the thermal pad can be attached directly to a ground or power plane (whichever is applicable), or alternatively, a special heatsink structure designed into the PCB. This design optimizes the heat transfer from the integrated circuit (IC).

For additional information on the PowerPAD package and how to take advantage of its heat dissipating abilities, refer to Technical Brief, PowerPAD Thermally Enhanced Package, Texas Instruments Literature No. SLMA002 and Application Brief, PowerPAD Made Easy, Texas Instruments Literature No. SLMA004. Both documents are available at www.ti.com.

The exposed thermal pad dimensions for this package are shown in the following illustration.

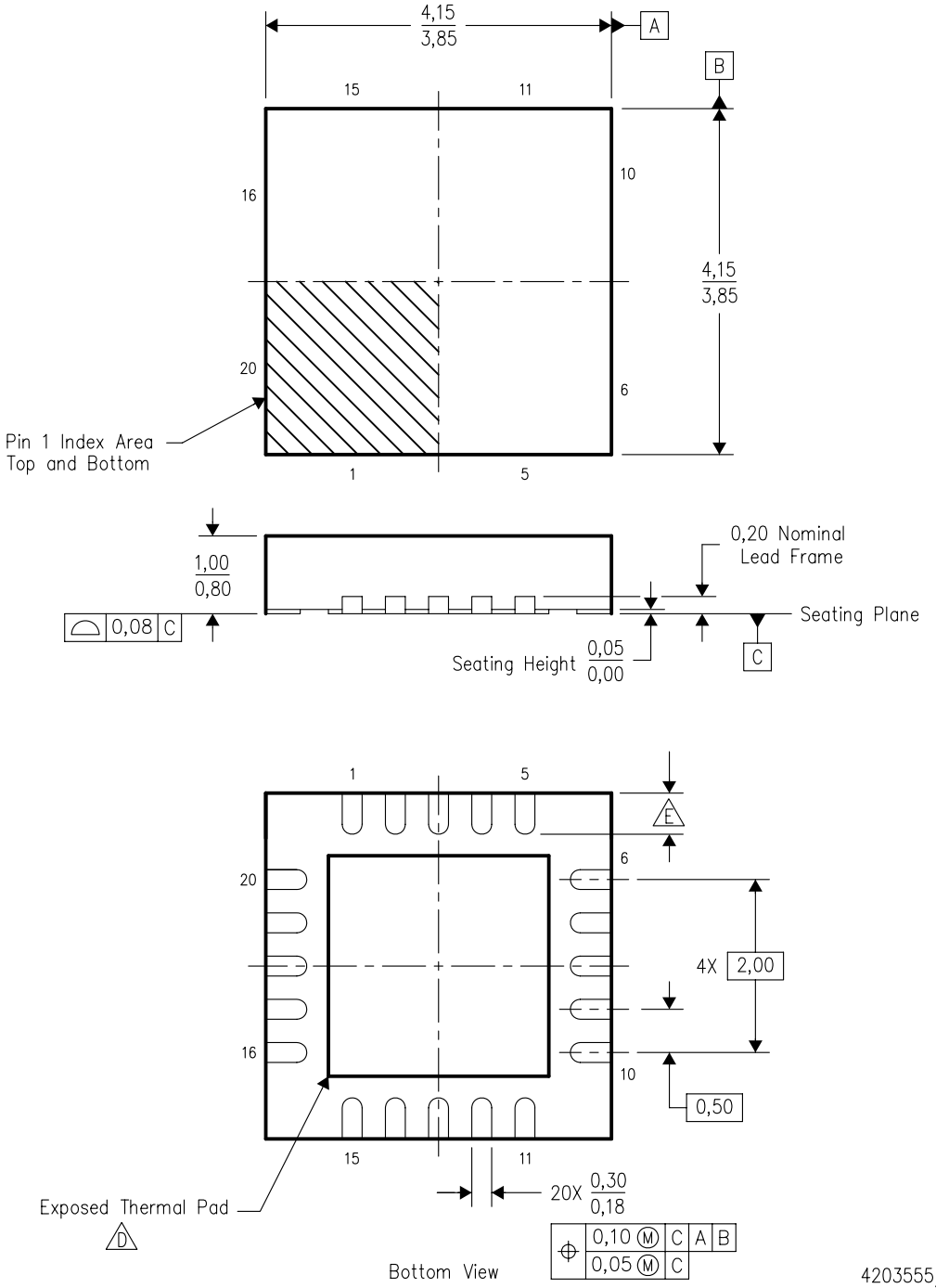



Top View

NOTE: All linear dimensions are in millimeters

Exposed Thermal Pad Dimensions

## RGP (S–PQFP–N20) PLASTIC QUAD FLATPACK



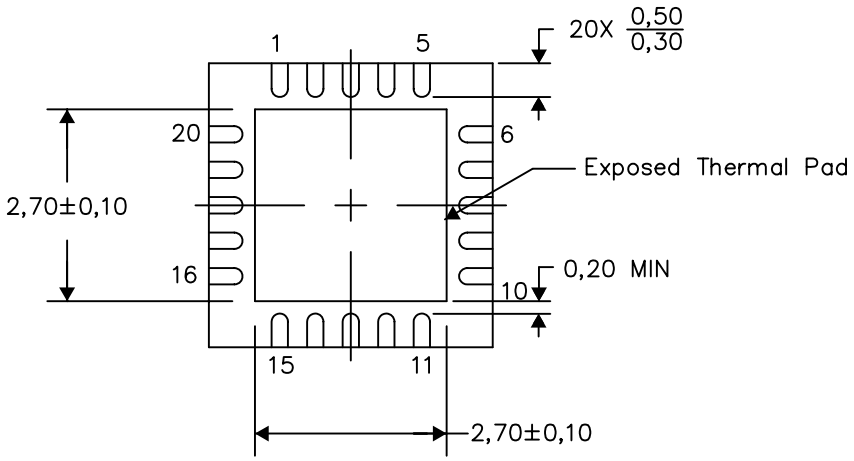

NOTES:
A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M–1994.
B. This drawing is subject to change without notice.
C. QFN (Quad Flatpack No–Lead) package configuration.
D. The package thermal pad must be soldered to the board for thermal and mechanical performance. See the Product Data Sheet for details regarding the exposed thermal pad dimensions.
E. Check thermal pad mechanical drawing in the product datasheet for nominal lead length dimensions.

## THERMAL INFORMATION

This package incorporates an exposed thermal pad that is designed to be attached directly to an external heatsink. The thermal pad must be soldered directly to the printed circuit board (PCB). After soldering, the PCB can be used as a heatsink. In addition, through the use of thermal vias, the thermal pad can be attached directly to a ground or power plane (whichever is applicable), or alternatively, a special heatsink structure designed into the PCB. This design optimizes the heat transfer from the integrated circuit (IC).

For information on the Quad Flatpack No–Lead (QFN) package and its advantages, refer to Application Report, Quad Flatpack No–Lead Logic Packages, Texas Instruments Literature No. SCBA017. This document is available at www.ti.com.

The exposed thermal pad dimensions for this package are shown in the following illustration.




Bottom View

NOTE: All linear dimensions are in millimeters

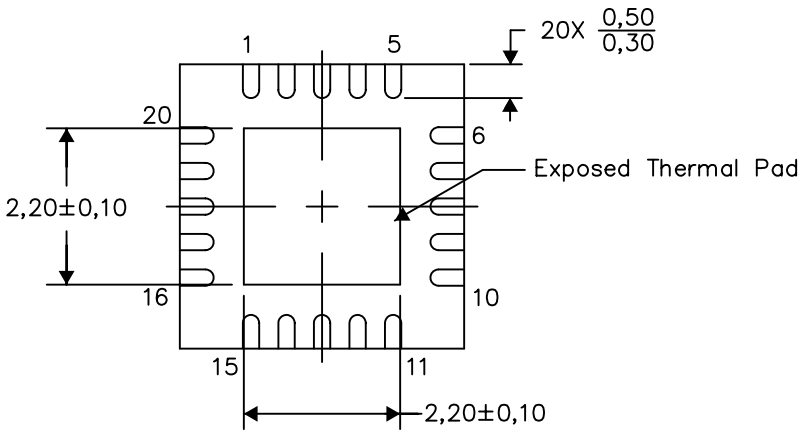
Exposed Thermal Pad Dimensions

## THERMAL INFORMATION

This package incorporates an exposed thermal pad that is designed to be attached directly to an external heatsink. The thermal pad must be soldered directly to the printed circuit board (PCB). After soldering, the PCB can be used as a heatsink. In addition, through the use of thermal vias, the thermal pad can be attached directly to a ground or power plane (whichever is applicable), or alternatively, a special heatsink structure designed into the PCB. This design optimizes the heat transfer from the integrated circuit (IC).

For information on the Quad Flatpack No–Lead (QFN) package and its advantages, refer to Application Report, Quad Flatpack No–Lead Logic Packages, Texas Instruments Literature No. SCBA017. This document is available at www.ti.com.

The exposed thermal pad dimensions for this package are shown in the following illustration.

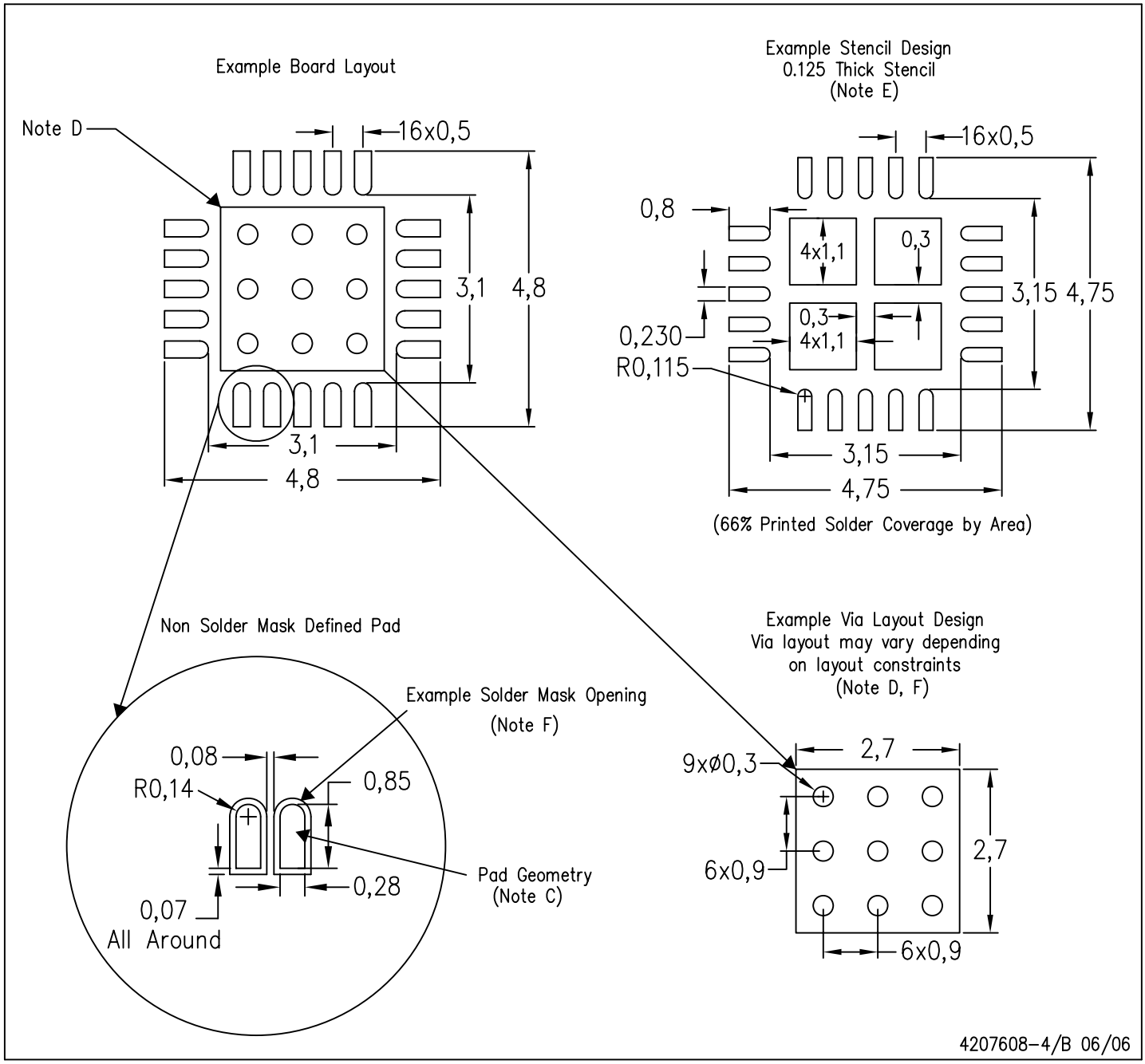



Bottom View

NOTE: All linear dimensions are in millimeters

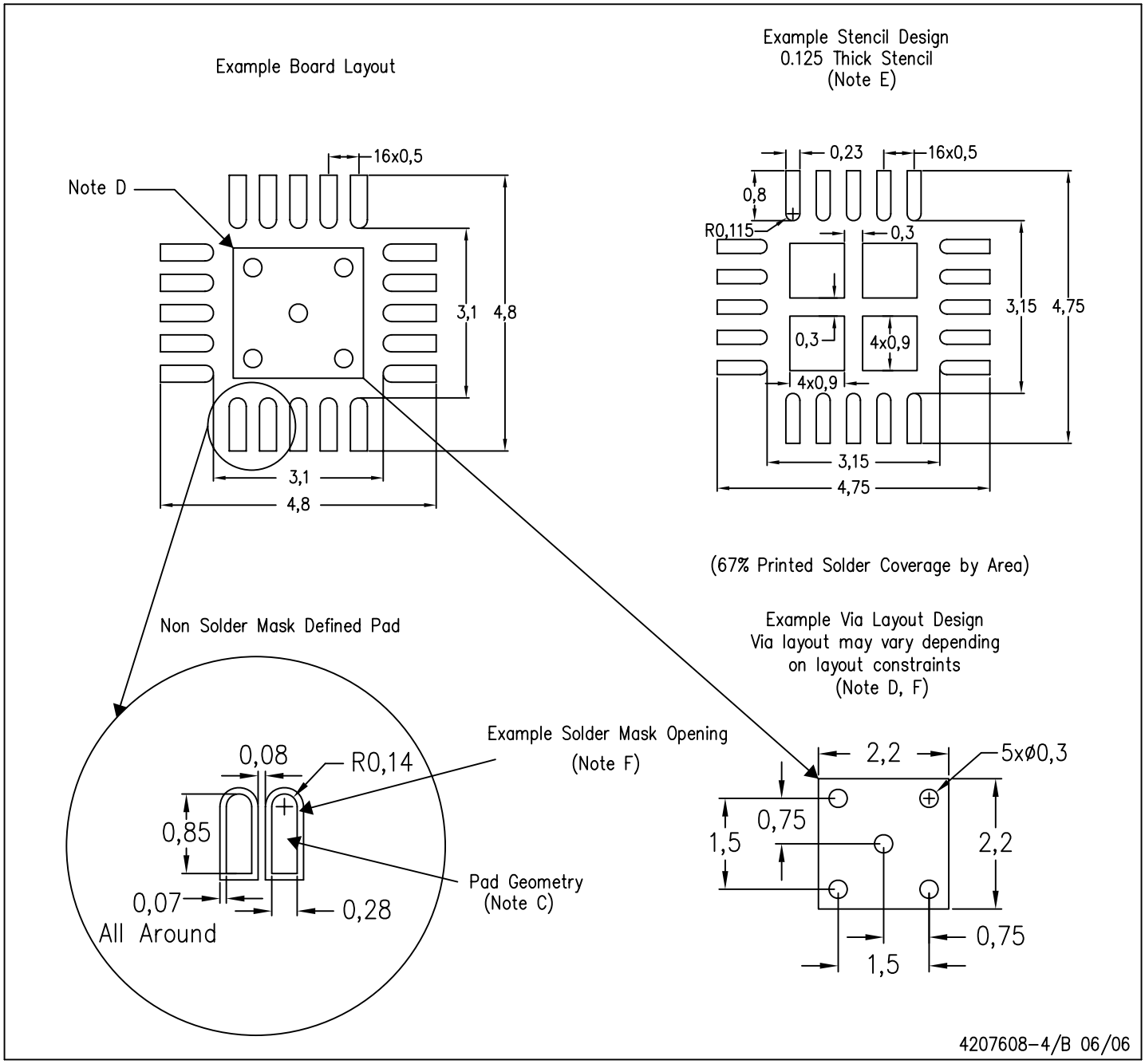
Exposed Thermal Pad Dimensions

TPS2231RGP RGP (S–PQFP–N20)




NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Publication IPC–7351 is recommended for alternate designs.
D. This package is designed to be soldered to a thermal pad on the board. Refer to Application Note, Quad Flat–Pack Packages, Texas Instruments Literature No. SCBA017, SLUA271, and also the Product Data Sheets for specific thermal information, via requirements, and recommended board layout. These documents are available at www.ti.com <http://www.ti.com>.
E. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC 7525 for stencil design considerations.
F. Customers should contact their board fabrication site for recommended solder mask tolerances and via tenting recommendations for vias placed in the thermal pad.

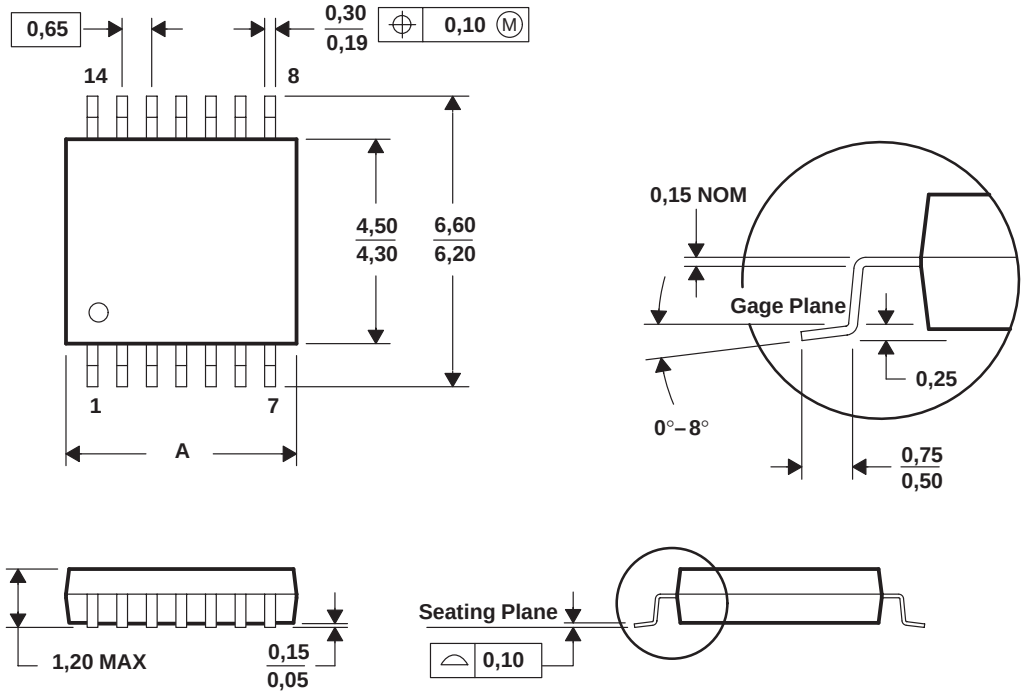
TPS2231MRGP RGP (S–PQFP–N20)




NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Publication IPC–7351 is recommended for alternate designs.
D. This package is designed to be soldered to a thermal pad on the board. Refer to Application Note, Quad Flat–Pack Packages, Texas Instruments Literature No. SCBA017, SLUA271, and also the Product Data Sheets for specific thermal information, via requirements, and recommended board layout. These documents are available at www.ti.com <http://www.ti.com>.
E. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should

**PW (R-PDSO-G**)** **PLASTIC SMALL-OUTLINE PACKAGE**

**14 PINS SHOWN**




| DIM \ PINS ** | 8 | 14 | 16 | 20 | 24 | 28 |
|---|---|---|---|---|---|---|
| A MAX | 3,10 | 5,10 | 5,10 | 6,60 | 7,90 | 9,80 |
| A MIN | 2,90 | 4,90 | 4,90 | 6,40 | 7,70 | 9,60 |

**4040064/F 01/97**

NOTES: A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion not to exceed 0,15.
D. Falls within JEDEC MO-153

## PACKAGING INFORMATION

| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead/Ball Finish | MSL Peak Temp (3) |
|---|---|---|---|---|---|---|---|---|
| TPS2231MRGPR | ACTIVE | QFN | RGP | 20 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR |
| TPS2231MRGPR-1 | ACTIVE | QFN | RGP | 20 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR |
| TPS2231MRGPR-1G4 | ACTIVE | QFN | RGP | 20 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR |
| TPS2231MRGPR-2 | PREVIEW | QFN | RGP | 20 | 3000 | TBD | Call TI | Call TI |
| TPS2231MRGPRG4 | ACTIVE | QFN | RGP | 20 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR |
| TPS2231MRGPT | ACTIVE | QFN | RGP | 20 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR |
| TPS2231MRGPT-1 | ACTIVE | QFN | RGP | 20 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR |
| TPS2231MRGPT-1G4 | ACTIVE | QFN | RGP | 20 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR |
| TPS2231MRGPTG4 | ACTIVE | QFN | RGP | 20 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR |
| TPS2231PW | ACTIVE | TSSOP | PW | 20 | 70 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TPS2231PWG4 | ACTIVE | TSSOP | PW | 20 | 70 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TPS2231PWP | ACTIVE | HTSSOP | PWP | 24 | 60 | Green (RoHS & no Sb/Br) | Call TI | Level-2-260C-1 YEAR |
| TPS2231PWPG4 | ACTIVE | HTSSOP | PWP | 24 | 60 | Green (RoHS & no Sb/Br) | Call TI | Level-2-260C-1 YEAR |
| TPS2231PWPR | ACTIVE | HTSSOP | PWP | 24 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR |
| TPS2231PWPRG4 | ACTIVE | HTSSOP | PWP | 24 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR |
| TPS2231PWR | ACTIVE | TSSOP | PW | 20 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TPS2231PWRG4 | ACTIVE | TSSOP | PW | 20 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TPS2231RGPR | ACTIVE | QFN | RGP | 20 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR |
| TPS2231RGPRG4 | ACTIVE | QFN | RGP | 20 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR |
| TPS2231RGPT | ACTIVE | QFN | RGP | 20 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR |
| TPS2231RGPTG4 | ACTIVE | QFN | RGP | 20 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR |
| TPS2236DAP | ACTIVE | HTSSOP | DAP | 32 | 46 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-3-260C-168 HR |
| TPS2236DAPG4 | ACTIVE | HTSSOP | DAP | 32 | 46 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-3-260C-168 HR |
| TPS2236DAPR | ACTIVE | HTSSOP | DAP | 32 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-3-260C-168 HR |
| TPS2236DAPRG4 | ACTIVE | HTSSOP | DAP | 32 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-3-260C-168 HR |

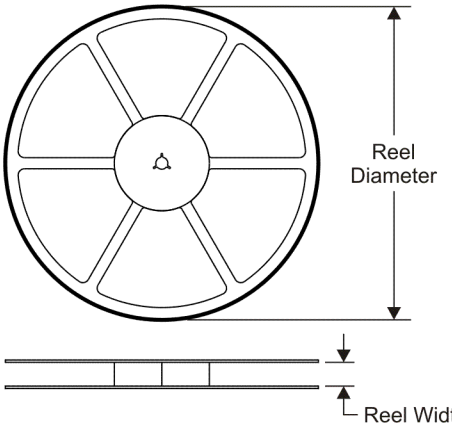
(1) The marketing status values are defined as follows:
**ACTIVE:** Product device recommended for new designs.
**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
**NRND:** Not recommended for new designs. Device is in production to support existing 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)

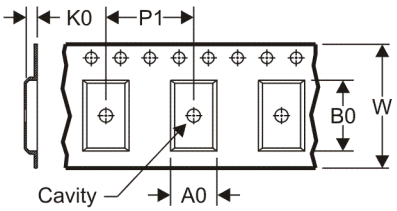
(3) MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

## TAPE AND REEL INFORMATION

**REEL DIMENSIONS**

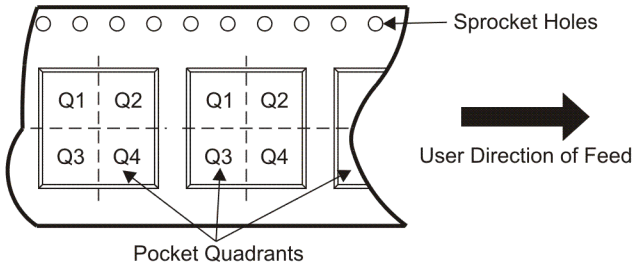



**TAPE DIMENSIONS**




| | |
|---|---|
| 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 |

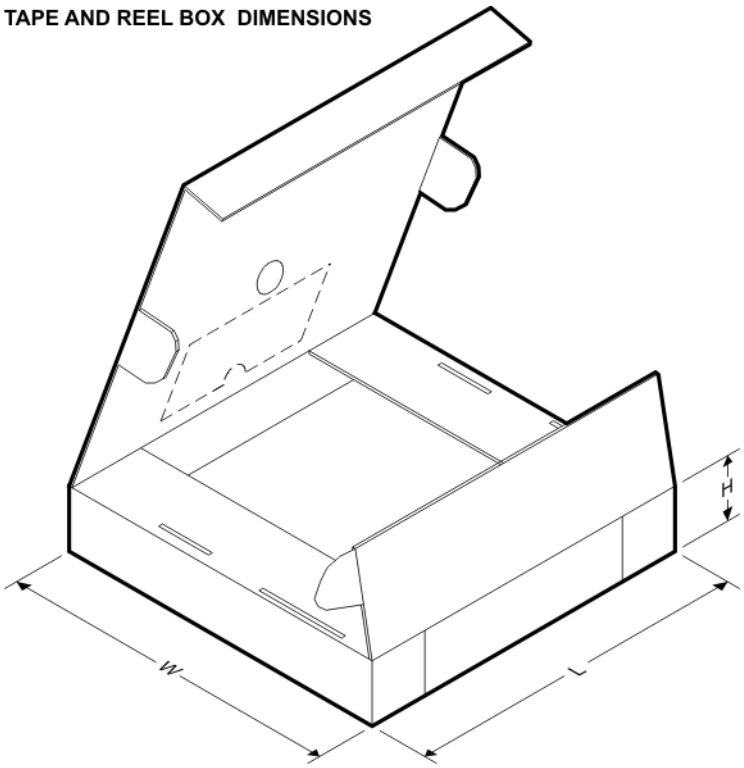
**QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE**




*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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TPS2231MRGPR | QFN | RGP | 20 | 3000 | 330.0 | 12.4 | 4.3 | 4.3 | 1.1 | 8.0 | 12.0 | Q2 |
| TPS2231MRGPR | QFN | RGP | 20 | 3000 | 330.0 | 12.4 | 4.3 | 4.3 | 1.5 | 8.0 | 12.0 | Q2 |
| TPS2231MRGPR-1 | QFN | RGP | 20 | 3000 | 330.0 | 12.4 | 4.3 | 4.3 | 1.5 | 8.0 | 12.0 | Q3 |
| TPS2231MRGPR-1 | QFN | RGP | 20 | 3000 | 330.0 | 12.4 | 4.3 | 4.3 | 1.1 | 8.0 | 12.0 | Q3 |
| TPS2231MRGPT | QFN | RGP | 20 | 250 | 180.0 | 12.4 | 4.3 | 4.3 | 1.1 | 8.0 | 12.0 | Q2 |
| TPS2231MRGPT | QFN | RGP | 20 | 250 | 180.0 | 12.4 | 4.3 | 4.3 | 1.5 | 8.0 | 12.0 | Q2 |
| TPS2231MRGPT-1 | QFN | RGP | 20 | 250 | 180.0 | 12.4 | 4.3 | 4.3 | 1.5 | 8.0 | 12.0 | Q3 |
| TPS2231PWPR | HTSSOP | PWP | 24 | 2000 | 330.0 | 16.4 | 6.95 | 8.3 | 1.6 | 8.0 | 16.0 | Q1 |
| TPS2231PWR | TSSOP | PW | 20 | 2000 | 330.0 | 16.4 | 6.95 | 7.1 | 1.6 | 8.0 | 16.0 | Q1 |
| TPS2231RGPR | QFN | RGP | 20 | 3000 | 330.0 | 12.4 | 4.3 | 4.3 | 1.5 | 8.0 | 12.0 | Q2 |
| TPS2231RGPR | QFN | RGP | 20 | 3000 | 330.0 | 12.4 | 4.3 | 4.3 | 1.1 | 8.0 | 12.0 | Q2 |
| TPS2231RGPT | QFN | RGP | 20 | 250 | 180.0 | 12.4 | 4.3 | 4.3 | 1.5 | 8.0 | 12.0 | Q2 |
| TPS2231RGPT | QFN | RGP | 20 | 250 | 180.0 | 12.4 | 4.3 | 4.3 | 1.1 | 8.0 | 12.0 | Q2 |
| TPS2236DAPR | HTSSOP | DAP | 32 | 2000 | 330.0 | 24.4 | 8.6 | 11.5 | 1.6 | 12.0 | 24.0 | Q1 |

**TAPE AND REEL BOX DIMENSIONS**




*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|---|---|---|---|---|---|---|---|
| TPS2231MRGPR | QFN | RGP | 20 | 3000 | 370.0 | 355.0 | 55.0 |
| TPS2231MRGPR | QFN | RGP | 20 | 3000 | 346.0 | 346.0 | 29.0 |
| TPS2231MRGPR-1 | QFN | RGP | 20 | 3000 | 346.0 | 346.0 | 29.0 |
| TPS2231MRGPR-1 | QFN | RGP | 20 | 3000 | 370.0 | 355.0 | 55.0 |
| TPS2231MRGPT | QFN | RGP | 20 | 250 | 195.0 | 200.0 | 45.0 |
| TPS2231MRGPT | QFN | RGP | 20 | 250 | 190.5 | 212.7 | 31.8 |
| TPS2231MRGPT-1 | QFN | RGP | 20 | 250 | 190.5 | 212.7 | 31.8 |
| TPS2231PWPR | HTSSOP | PWP | 24 | 2000 | 346.0 | 346.0 | 33.0 |
| TPS2231PWR | TSSOP | PW | 20 | 2000 | 346.0 | 346.0 | 33.0 |
| TPS2231RGPR | QFN | RGP | 20 | 3000 | 346.0 | 346.0 | 29.0 |
| TPS2231RGPR | QFN | RGP | 20 | 3000 | 370.0 | 355.0 | 55.0 |
| TPS2231RGPT | QFN | RGP | 20 | 250 | 190.5 | 212.7 | 31.8 |
| TPS2231RGPT | QFN | RGP | 20 | 250 | 195.0 | 200.0 | 45.0 |
| TPS2236DAPR | HTSSOP | DAP | 32 | 2000 | 346.0 | 346.0 | 41.0 |

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