

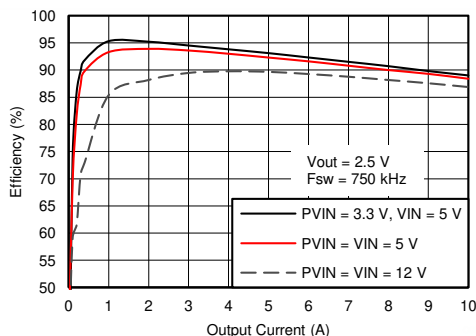
# TPS84A20 2.95V 至 17V 输入、10A 同步降压集成式电源解决方案

## 1 特性

- 完整的集成式电源解决方案可实现小尺寸和扁平设计
- 10mm × 10mm × 4.3mm 封装
- 效率最高可达 95%
- Eco-mode™/轻负载效率 (LLE)
- 宽输出电压调节范围为 0.6V 至 5.5V，基准精度为 1%
- 支持针对更高电流的并行运行
- 可选分离电源轨可实现低至 2.95V 的输入电压
- 可调节的开关频率范围 (200kHz 至 1.2MHz)
- 与外部时钟同步
- 提供 180° 异相位时钟信号
- 可调慢速启动
- 输出电压排序/跟踪
- 电源正常输出
- 可编程欠压锁定 (UVLO)
- 过流和过热保护
- 预偏置输出启动
- 工作温度范围: -40°C 至 +85°C
- 增强的散热性能: 13.3°C/W
- 符合 EN55022 B 类辐射标准

## 2 应用

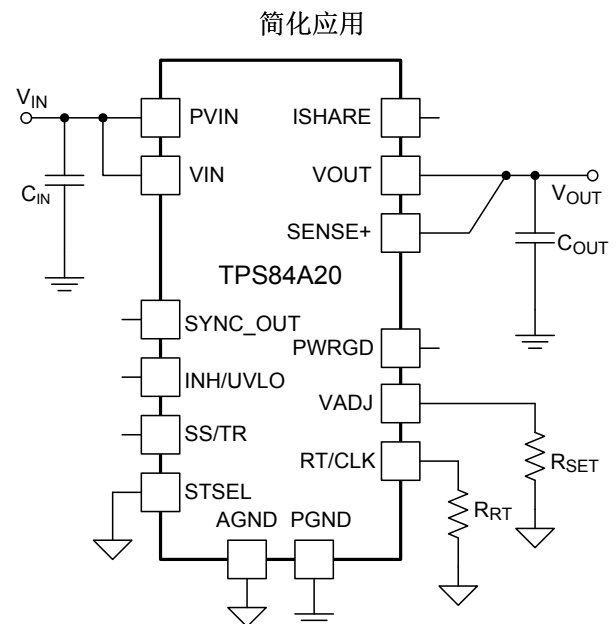
- 宽带和通信基础设施
- 自动测试和医疗设备
- 紧凑型 PCI/PCI 快速接口/PXI 快速接口
- DSP 和 FPGA 负载点应用



## 3 说明

TPS84A20 是一个简单易用的集成式电源解决方案，它在一个小外形尺寸的 QFN 封装内整合了一个带有功率 MOSFET 的 10A 直流/直流转换器、一个电感器以及无源器件。此整体电源解决方案仅需三个外部组件，并省去了环路补偿和磁性元件选择过程。

此器件采用 10mm × 10mm × 4.3mm QFN 封装，可轻松焊接到印刷电路板上，并可实现紧凑的负载点设计。可实现超过 95% 的效率，具有热阻为 13.3°C/W 的出色功率耗散能力。TPS84A20 提供离散负载点设计的灵活性和特性集，并且非常适合为广泛的集成电路 (IC) 和系统供电。先进的封装技术可提供一个与标准 QFN 贴装和测试技术兼容的稳健耐用且可靠的电源解决方案。



## 4 修订历史记录

注：之前版本的页码可能与当前版本有所不同。

### Changes from Revision B (April 2018) to Revision C Page

- Added  $V_{OUT}$  Range values under different  $I_{OUT}$  conditions in [Table 9](#) ..... 24

### Changes from Revision A (June 2017) to Revision B Page

- 已添加 TI 参考设计顶部导航图标 ..... 1
- Increased the peak reflow temperature and maximum number of reflows to JEDEC specification for improved manufacturability ..... 3
- 添加机械、封装和可订购信息 部分 ..... 30

### Changes from Original (MARCH 2013) to Revision A Page

- Added peak reflow and maximum number of reflows information ..... 3
- Added Parallel Operation section ..... 19

**Table 1. Ordering Information**

For the most current package and ordering information, see the Package Option Addendum at the end of this datasheet, or see the TI website at [www.ti.com](http://www.ti.com).

## 5 Specifications

### 5.1 Absolute Maximum Ratings<sup>(1)</sup>

| over operating temperature range (unless otherwise noted) |  | MIN  | MAX                | UNIT |
|---|--|------|--------------------|------|
| Input Voltage   | VIN, PVIN  | −0.3 | 20                 | V    |
|   | INH/UVLO, PWRGD, RT/CLK, SENSE+                        | −0.3 | 6                  | V    |
|   | ILIM, VADJ, SS/TR, STSEL, SYNC_OUT, ISHARE, OCP_SEL    | −0.3 | 3                  | V    |
| Output Voltage  | PH   | −1.0 | 20                 | V    |
|   | PH 10ns Transient                                      | −3.0 | 20                 | V    |
|   | VOUT   | −0.3 | 6                  | V    |
| Source Current  | RT/CLK, INH/UVLO                                       |      | ±100               | μA   |
|   | PH   |      | current limit      | A    |
| Sink Current  | PH   |      | current limit      | A    |
|   | PVIN   |      | current limit      | A    |
|   | PWRGD  | −0.1 | 2                  | mA   |
| Operating Junction Temperature                            |  | −40  | 125 <sup>(2)</sup> | °C   |
| Storage Temperature                                       |  | −65  | 150                | °C   |
| Peak Reflow Case Temperature <sup>(3)(4)</sup>            |  |      | 245                | °C   |
| Maximum Number of Reflows Allowed <sup>(3)(4)</sup>       |  |      | 3                  |      |
| Mechanical Shock  | Mil-STD-883D, Method 2002.3, 1 msec, 1/2 sine, mounted |      | 1500               | G    |
| Mechanical Vibration                                      | Mil-STD-883D, Method 2007.2, 20-2000Hz                 |      | 20                 |      |

- (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) See the temperature derating curves in the Typical Characteristics section for thermal information.
- (3) For soldering specifications, refer to the [Soldering Requirements for BQFN Packages](#) application note.
- (4) Devices with a date code prior to week 14 2018 (1814) have a peak reflow case temperature of 240°C with a maximum of one reflow.

### 5.2 Recommended Operating Conditions

| over operating free-air temperature range (unless otherwise noted) |                         | MIN  | NOM | MAX  | UNIT |
|--|-------------------------|------|-----|------|------|
| PVIN   | Input Switching Voltage | 2.95 |     | 17   | V    |
| VIN  | Input Bias Voltage      | 4.5  |     | 17   | V    |
| VOUT   | Output Voltage          | 0.6  |     | 5.5  | V    |
| fSW  | Switching Frequency     | 200  |     | 1200 | kHz  |

### 5.3 Package Specifications

| TPS84A20                    |   | UNIT       |
|-----------------------------|---|------------|
| Weight                      |   | 1.45 grams |
| Flammability                | Meets UL 94 V-O   |            |
| MTBF Calculated reliability | Per Bellcore TR-332, 50% stress, TA = 40°C, ground benign | 37.4 Mhrs  |

## 5.4 Electrical Characteristics

Over  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$  free-air temperature,  $P_{VIN} = V_{IN} = 12\text{ V}$ ,  $V_{OUT} = 1.8\text{ V}$ ,  $I_{OUT} = 10\text{ A}$ ,  
 $C_{IN} = 0.1\text{ }\mu\text{F} + 2 \times 22\text{ }\mu\text{F}$  ceramic +  $100\text{ }\mu\text{F}$  bulk,  $C_{OUT} = 4 \times 47\text{ }\mu\text{F}$  ceramic (unless otherwise noted)

| PARAMETER             |                                      | TEST CONDITIONS   |   | MIN                 | TYP  | MAX                  | UNIT |
|-----------------------|--------------------------------------|---|---|---------------------|------|----------------------|------|
| I <sub>OUT</sub>      | Output current                       | T <sub>A</sub> = 85°C, natural convection                         |   | 0 <sup>(1)</sup>    |      | 10                   | A    |
| V <sub>IN</sub>       | Input bias voltage range             | Over output current range   |   | 4.5                 |      | 17                   | V    |
| PV <sub>IN</sub>      | Input switching voltage range        | Over output current range   |   | 2.95 <sup>(2)</sup> |      | 17 <sup>(3)</sup>    | V    |
| UVLO                  | V <sub>IN</sub> Undervoltage lockout | V <sub>IN</sub> Increasing  |   | 4.0                 |      | 4.5                  | V    |
|                       |                                      | V <sub>IN</sub> Decreasing  |   | 3.5                 | 3.85 |                      |      |
| V <sub>OUT(adj)</sub> | Output voltage adjust range          | Over output current range   |   | 0.6                 |      | 5.5                  | V    |
| V <sub>OUT</sub>      | Set-point voltage tolerance          | T <sub>A</sub> = 25°C, I <sub>OUT</sub> = 0 A                     |   |                     |      | ±1% <sup>(4)</sup>   |      |
|                       | Temperature variation                | −40°C ≤ T <sub>A</sub> ≤ +85°C, I <sub>OUT</sub> = 0 A            |   |                     |      | ±0.2%                |      |
|                       | Line regulation                      | Over input voltage range  |   |                     |      | ±0.1%                |      |
|                       | Load regulation                      | Over output current range   |   |                     |      | ±0.2%                |      |
|                       | Total output voltage variation       | Includes set-point, line, load, and temperature variation         |   |                     |      | ±1.5% <sup>(4)</sup> |      |
| η                     | Efficiency                           | P <sub>VIN</sub> = V <sub>IN</sub> = 12 V<br>I <sub>O</sub> = 5 A | V <sub>OUT</sub> = 5.0 V, f <sub>SW</sub> = 1 MHz   | 93 %                |      |                      |      |
|                       |                                      |   | V <sub>OUT</sub> = 3.3 V, f <sub>SW</sub> = 750 kHz | 92 %                |      |                      |      |
|                       |                                      |   | V <sub>OUT</sub> = 2.5 V, f <sub>SW</sub> = 750 kHz | 90 %                |      |                      |      |
|                       |                                      |   | V <sub>OUT</sub> = 1.8 V, f <sub>SW</sub> = 500 kHz | 89 %                |      |                      |      |
|                       |                                      |   | V <sub>OUT</sub> = 1.2 V, f <sub>SW</sub> = 300 kHz | 86 %                |      |                      |      |
|                       |                                      |   | V <sub>OUT</sub> = 0.9 V, f <sub>SW</sub> = 250 kHz | 84 %                |      |                      |      |
|                       |                                      |   | V <sub>OUT</sub> = 0.6 V, f <sub>SW</sub> = 200 kHz | 81 %                |      |                      |      |
|                       |                                      | P <sub>VIN</sub> = V <sub>IN</sub> = 5 V<br>I <sub>O</sub> = 5 A  | V <sub>OUT</sub> = 3.3 V, f <sub>SW</sub> = 750 kHz | 94 %                |      |                      |      |
|                       |                                      |   | V <sub>OUT</sub> = 2.5 V, f <sub>SW</sub> = 750 kHz | 93 %                |      |                      |      |
|                       |                                      |   | V <sub>OUT</sub> = 1.8 V, f <sub>SW</sub> = 500 kHz | 92 %                |      |                      |      |
|                       |                                      |   | V <sub>OUT</sub> = 1.2 V, f <sub>SW</sub> = 300 kHz | 89 %                |      |                      |      |
|                       |                                      |   | V <sub>OUT</sub> = 0.9 V, f <sub>SW</sub> = 250 kHz | 87 %                |      |                      |      |
|                       |                                      |   | V <sub>OUT</sub> = 0.6 V, f <sub>SW</sub> = 200 kHz | 83 %                |      |                      |      |
| Output voltage ripple |                                      | 20 MHz bandwidth  |   | 14                  |      | mV <sub>P-P</sub>    |      |
| I <sub>LIM</sub>      | Current limit threshold              | ILIM pin open   |   | 15                  |      | A                    |      |
|                       |                                      | ILIM pin to AGND  |   | 12                  |      | A                    |      |
| Transient response    |                                      | 1.0 A/μs load step from<br>25 to 75% I <sub>OUT(max)</sub>        | Recovery time                                       |                     | 100  |                      | μs   |
|                       |                                      |   | VOUT over/undershoot                                |                     | 80   |                      | mV   |
| V <sub>INH</sub>      | Inhibit threshold voltage            | Inhibit High Voltage  |   | 1.3                 |      | open <sup>(5)</sup>  | V    |
|                       |                                      | Inhibit Low Voltage   |   | -0.3                |      | 1.1                  |      |
| I <sub>INH</sub>      | INH Input current                    | V <sub>INH</sub> < 1.1 V  |   | -1.15               |      |                      | μA   |
|                       | INH Hysteresis current               | V <sub>INH</sub> > 1.3 V  |   | -3.3                |      |                      | μA   |
| I <sub>I(stby)</sub>  | Input standby current                | INH pin to AGND   |   | 2                   |      | 10                   | μA   |
| Power Good            | PWRGD Thresholds                     | V <sub>OUT</sub> rising   | Good  | 95%                 |      |                      |      |
|                       |                                      |   | Fault   | 108%                |      |                      |      |
|                       |                                      | V <sub>OUT</sub> falling  | Fault   | 91%                 |      |                      |      |
|                       |                                      |   | Good  | 104%                |      |                      |      |
|                       | PWRGD Low Voltage                    |   | I(PWRGD) = 0.5 mA                                   |                     | 0.3  |                      | V    |
| f <sub>SW</sub>       | Switching frequency                  | R <sub>RT</sub> = 169 kΩ  |   | 400                 | 500  | 600                  | kHz  |
| f <sub>CLK</sub>      | Synchronization frequency            | CLK Control   |   | 200                 |      | 1200                 | kHz  |
| V <sub>CLK-H</sub>    | CLK High-Level                       |   |   | 2.0                 |      | 5.5                  | V    |
| V <sub>CLK-L</sub>    | CLK Low-Level                        |   |   |                     |      | 0.5                  | V    |
| D <sub>CLK</sub>      | CLK Duty Cycle                       |   |   | 20                  | 50   | 80                   | %    |

(1) See [Light Load Efficiency \(LLE\)](#) section for more information for output voltages  $< 1.5\text{ V}$ .

(2) The minimum  $P_{VIN}$  is 2.95 V or ( $V_{OUT} + 0.7\text{ V}$ ), whichever is greater. See [Table 9](#) for more details.

(3) The maximum  $PV_{IN}$  voltage is 17 V or ( $22 \times V_{OUT}$ ), whichever is less. See [Table 9](#) for more details.

(4) The stated limit of the set-point voltage tolerance includes the tolerance of both the internal voltage reference and the internal adjustment resistor. The overall output voltage tolerance will be affected by the tolerance of the external  $R_{SET}$  resistor.

(5) Value when no voltage divider is present at the INH/UVLO pin. This pin has an internal pull-up. If it is left open, the device operates when input power is applied. A small, low-leakage MOSFET is recommended for control. Do not tie this pin to VIN.

## Electrical Characteristics (continued)

Over  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$  free-air temperature,  $PV_{\text{IN}} = V_{\text{IN}} = 12\text{ V}$ ,  $V_{\text{OUT}} = 1.8\text{ V}$ ,  $I_{\text{OUT}} = 10\text{ A}$ ,  
 $C_{\text{IN}} = 0.1\text{ }\mu\text{F} + 2 \times 22\text{ }\mu\text{F ceramic} + 100\text{ }\mu\text{F bulk}$ ,  $C_{\text{OUT}} = 4 \times 47\text{ }\mu\text{F ceramic}$  (unless otherwise noted)

| PARAMETER                                    | TEST CONDITIONS                    | MIN               | TYP                | MAX                 | UNIT               |
|--|------------------------------------|-------------------|--------------------|---------------------|--------------------|
| Thermal Shutdown                             | Thermal shutdown                   |                   | 175                |                     | $^{\circ}\text{C}$ |
|  | Thermal shutdown hysteresis        |                   | 10                 |                     | $^{\circ}\text{C}$ |
| $C_{\text{IN}}$ External input capacitance   | Ceramic                            | 44 <sup>(6)</sup> |                    |                     | $\mu\text{F}$      |
|  | Non-ceramic                        |                   | 100 <sup>(6)</sup> |                     |                    |
| $C_{\text{OUT}}$ External output capacitance | Ceramic                            | 47 <sup>(7)</sup> | 200                | 1500                | $\mu\text{F}$      |
|  | Non-ceramic                        |                   | 220 <sup>(7)</sup> | 5000 <sup>(8)</sup> |                    |
|  | Equivalent series resistance (ESR) |                   |                    | 35                  | $\text{m}\Omega$   |

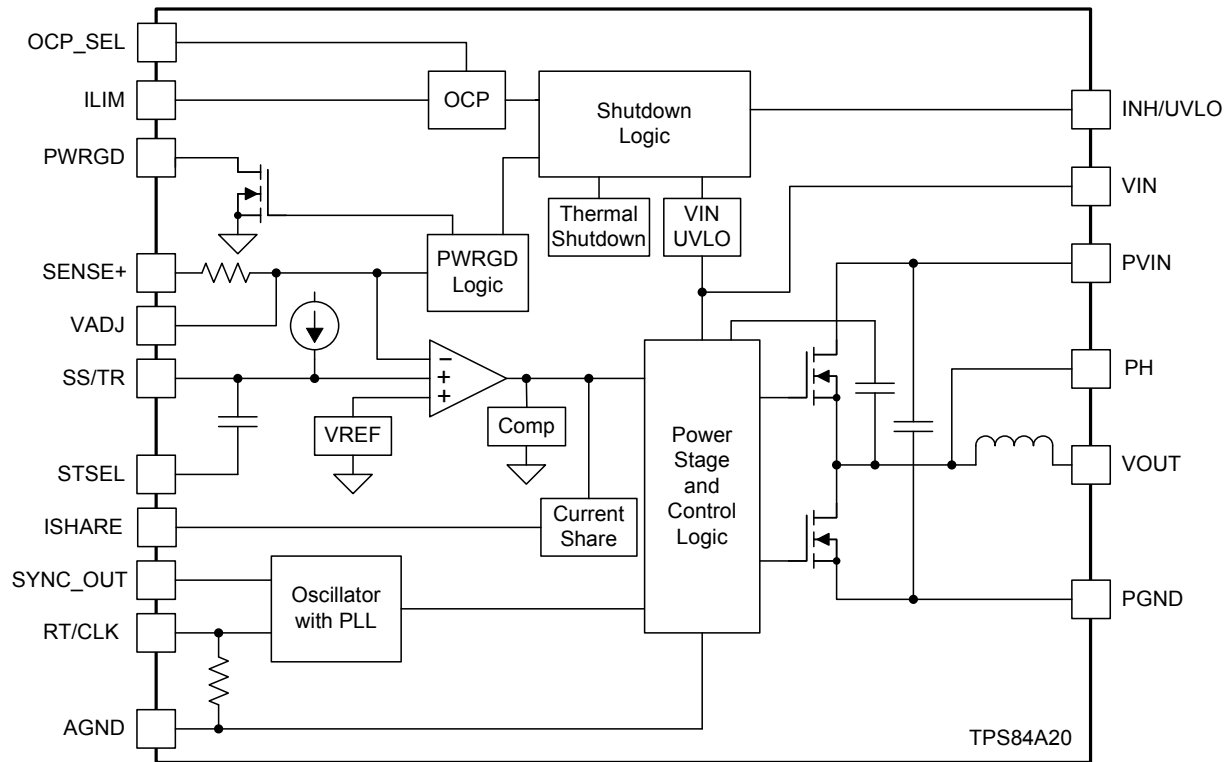
- (6) A minimum of 44  $\mu\text{F}$  of external ceramic capacitance is required across the input (VIN and PVIN connected) for proper operation. An additional 100  $\mu\text{F}$  of bulk capacitance is recommended. It is also recommended to place a 0.1- $\mu\text{F}$  ceramic capacitor directly across the PVIN and PGND pins of the device. Locate the input capacitance close to the device. When operating with split VIN and PVIN rails, place 4.7 $\mu\text{F}$  of ceramic capacitance directly at the VIN pin. See [Table 6](#) for more details.
- (7) The amount of required output capacitance varies depending on the output voltage (see [Table 5](#)). The amount of required capacitance must include at least 1x 47  $\mu\text{F}$  ceramic capacitor. Locate the capacitance close to the device. Adding additional capacitance close to the load improves the response of the regulator to load transients. See [Table 5](#) and [Table 6](#) more details.
- (8) The maximum output capacitance of 5000  $\mu\text{F}$  includes the combination of both ceramic and non-ceramic capacitors.

## 5.5 Thermal Information

| THERMAL METRIC <sup>(1)</sup> |   | TPS84A20 | UNIT                        |
|-------------------------------|---|----------|-----------------------------|
|                               |   | RVQ42    |                             |
|                               |   | 42 PINS  |                             |
| $\theta_{\text{JA}}$          | Junction-to-ambient thermal resistance <sup>(2)</sup>       | 13.3     | $^{\circ}\text{C}/\text{W}$ |
| $\psi_{\text{JT}}$            | Junction-to-top characterization parameter <sup>(3)</sup>   | 1.6      |                             |
| $\psi_{\text{JB}}$            | Junction-to-board characterization parameter <sup>(4)</sup> | 5.3      |                             |

- (1) For more information about traditional and new thermal metrics, see the [IC Package Thermal Metrics Application Report](#).
- (2) The junction-to-ambient thermal resistance,  $\theta_{\text{JA}}$ , applies to devices soldered directly to a 100-mm x 100-mm double-sided PCB with 2 oz. copper and natural convection cooling. Additional airflow reduces  $\theta_{\text{JA}}$ .
- (3) The junction-to-top characterization parameter,  $\psi_{\text{JT}}$ , estimates the junction temperature,  $T_{\text{J}}$ , of a device in a real system, using a procedure described in JESD51-2A (sections 6 and 7).  $T_{\text{J}} = \psi_{\text{JT}} * P_{\text{dis}} + T_{\text{T}}$ ; where  $P_{\text{dis}}$  is the power dissipated in the device and  $T_{\text{T}}$  is the temperature of the top of the device.
- (4) The junction-to-board characterization parameter,  $\psi_{\text{JB}}$ , estimates the junction temperature,  $T_{\text{J}}$ , of a device in a real system, using a procedure described in JESD51-2A (sections 6 and 7).  $T_{\text{J}} = \psi_{\text{JB}} * P_{\text{dis}} + T_{\text{B}}$ ; where  $P_{\text{dis}}$  is the power dissipated in the device and  $T_{\text{B}}$  is the temperature of the board 1mm from the device.

## 6 Device Information

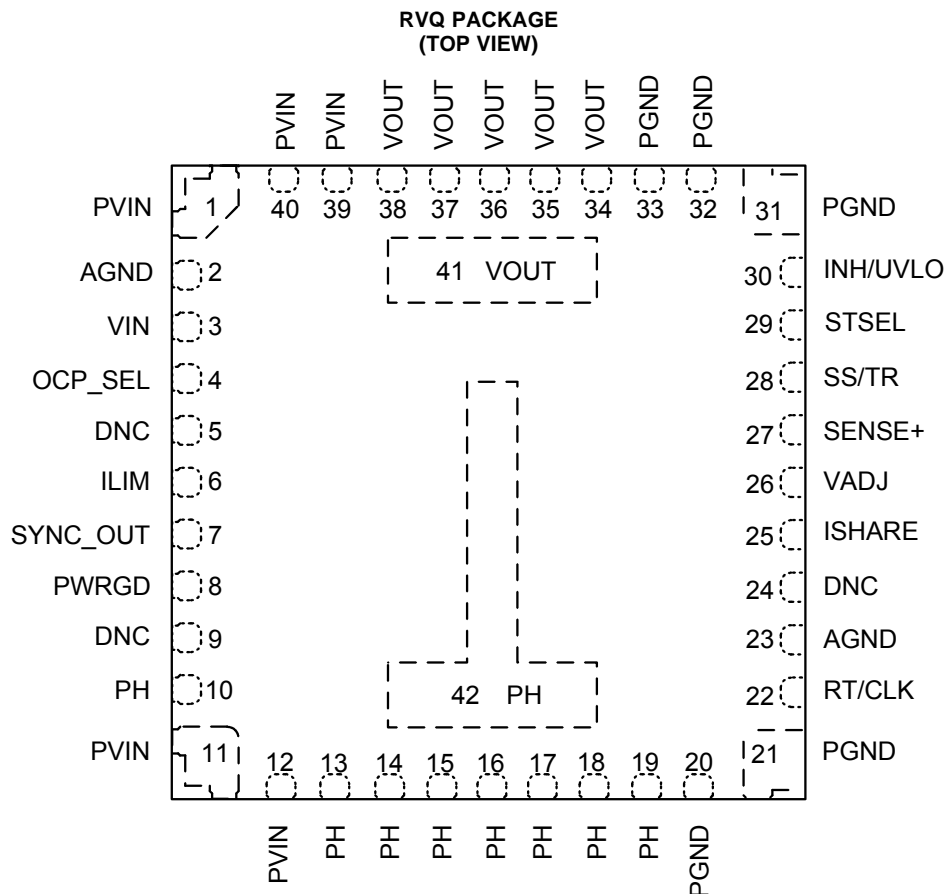
**Functional Block Diagram**


**Table 2. Pin Descriptions**

| TERMINAL |     | DESCRIPTION   |
|----------|-----|---|
| NAME     | NO. |   |
| AGND     | 2   | Zero volt reference for the analog control circuit. These pins are not connected together internal to the device and must be connected to one another using an AGND plane of the PCB. These pins are associated with the internal analog ground (AGND) of the device. See <a href="#">Layout Considerations</a> . |
|          | 23  |   |
| PGND     | 20  | This is the return current path for the power stage of the device. Connect these pins to the load and to the bypass capacitors associated with PVIN and VOUT.   |
|          | 21  |   |
|          | 31  |   |
|          | 32  |   |
|          | 33  |   |
| VIN      | 3   | Input bias voltage pin. Supplies the control circuitry of the power converter. Connect this pin to the input bias supply. Connect bypass capacitors between this pin and PGND.  |
| PVIN     | 1   | Input switching voltage. Supplies voltage to the power switches of the converter. Connect these pins to the input supply. Connect bypass capacitors between these pins and PGND.  |
|          | 11  |   |
|          | 12  |   |
|          | 39  |   |
|          | 40  |   |
| VOUT     | 34  | Output voltage. These pins are connected to the internal output inductor. Connect these pins to the output load and connect external bypass capacitors between these pins and PGND.   |
|          | 35  |   |
|          | 36  |   |
|          | 37  |   |
|          | 38  |   |
| PH       | 41  | Phase switch node. These pins must be connected to one another using a small copper island under the device for thermal relief. Do not place any external component on these pins or tie them to a pin of another function.   |
|          | 10  |   |
|          | 13  |   |
|          | 14  |   |
|          | 15  |   |
|          | 16  |   |
|          | 17  |   |
|          | 18  |   |
| DNC      | 19  | Do not connect. Do not connect these pins to AGND, to another DNC pin, or to any other voltage. These pins are connected to internal circuitry. Each pin must be soldered to an isolated pad.   |
|          | 42  |   |
|          | 5   |   |
| IShare   | 9   | Current share pin. Connect this pin to other TPS84A20 devices IShare pin when paralleling multiple TPS84A20 devices. When unused, treat this pin as a Do Not Connect (DNC) and leave it isolated from all other signals or ground.  |
|          | 24  |   |
| IShare   | 25  | Current share pin. Connect this pin to other TPS84A20 devices IShare pin when paralleling multiple TPS84A20 devices. When unused, treat this pin as a Do Not Connect (DNC) and leave it isolated from all other signals or ground.  |
| OCP_SEL  | 4   | Over current protection select pin. Leave this pin open for hiccup mode operation. Connect this pin to AGND for cycle-by-cycle operation. See <a href="#">Overcurrent Protection</a> for more details.  |
| ILIM     | 6   | Current limit pin. Leave this pin open for full current limit threshold. Connect this pin to AGND to reduce the current limit threshold by approximately 20%.   |
| SYNC_OUT | 7   | Synchronization output pin. Provides a 180° out-of-phase clock signal.  |
| PWRGD    | 8   | Power Good flag pin. This open drain output asserts low if the output voltage is more than approximately ±6% out of regulation. A pullup resistor is required.  |
| RT/CLK   | 22  | This pin is connected to an internal frequency setting resistor which sets the default switching frequency. An external resistor can be connected from this pin to AGND to increase the frequency. This pin can also be used to synchronize to an external clock.   |
| VADJ     | 26  | Connecting a resistor between this pin and AGND sets the output voltage.  |
| SENSE+   | 27  | Remote sense connection. This pin must be connected to VOUT at the load or at the device pins. Connect this pin to VOUT at the load for improved regulation.  |

**Table 2. Pin Descriptions (continued)**

| TERMINAL |     | DESCRIPTION  |
|----------|-----|--|
| NAME     | NO. |  |
| SS/TR    | 28  | Slow-start and tracking pin. Connecting an external capacitor to this pin adjusts the output voltage rise time. A voltage applied to this pin allows for tracking and sequencing control.                    |
| STSEL    | 29  | Slow-start or track feature select. Connect this pin to AGND to enable the internal SS capacitor. Leave this pin open to enable the TR feature.  |
| INH/UVLO | 30  | Inhibit and UVLO adjust pin. Use an open drain or open collector logic device to ground this pin to control the INH function. A resistor divider between this pin, AGND, and PVIN/VIN sets the UVLO voltage. |





## 7 Typical Characteristics (PVIN = VIN = 12 V)

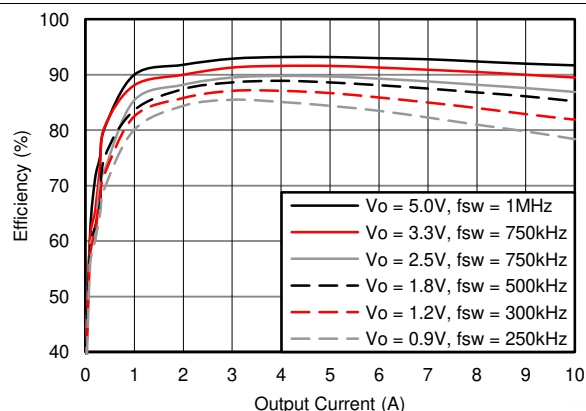


Figure 1. Efficiency versus Output Current

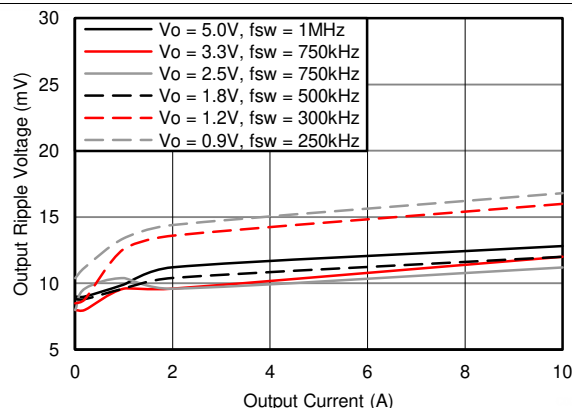


Figure 2. Voltage Ripple versus Output Current

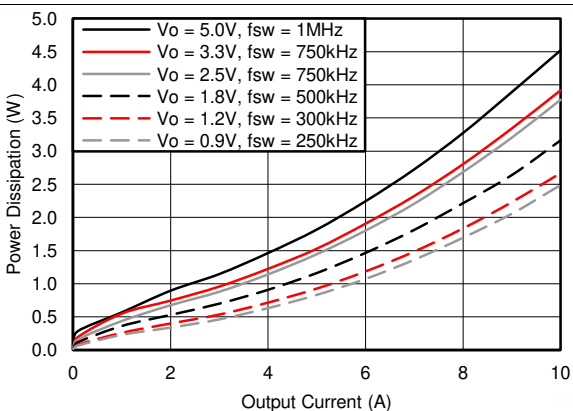


Figure 3. Power Dissipation versus Output Current

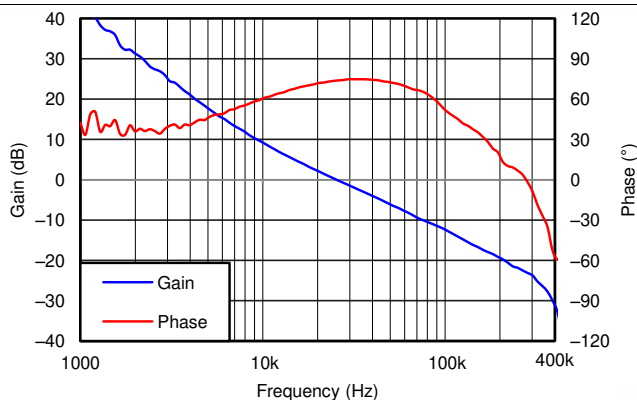


Figure 4.  $V_{OUT} = 1.8\text{ V}$ ,  $I_{OUT} = 10\text{ A}$ ,  $C_{OUT1} = 200\text{ }\mu\text{F}$  Ceramic,  $f_{sw} = 500\text{ kHz}$

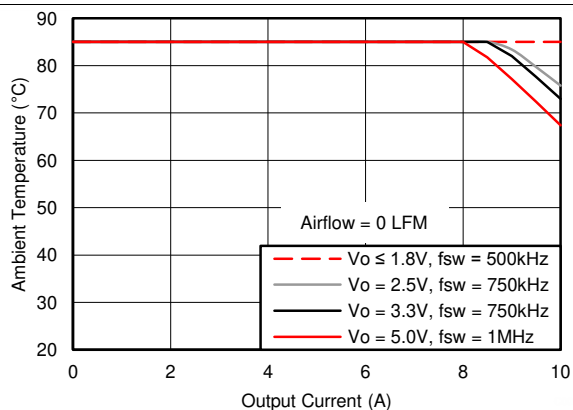


Figure 5. Safe Operating Area

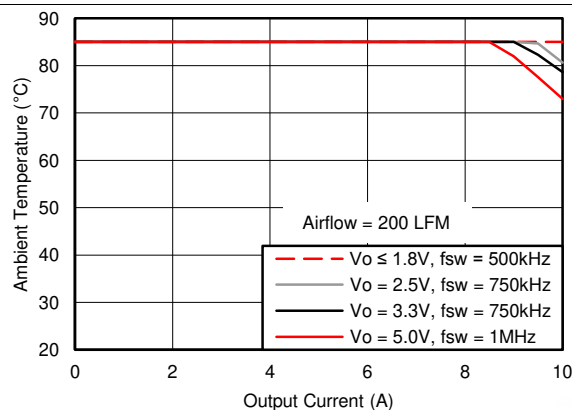


Figure 6. Safe Operating Area

The electrical characteristic data has been developed from actual products tested at 25°C. This data is considered typical for the converter. Applies to Figure 1, Figure 2, and Figure 3.

The temperature derating curves represent the conditions at which internal components are at or below the manufacturer's maximum operating temperatures. Derating limits apply to devices soldered directly to a 100-mm × 100-mm double-sided PCB with 2-oz. copper. Applies to Figure 5 and Figure 6.

## 8 Typical Characteristics (PVIN = VIN = 5 V)

The electrical characteristic data has been developed from actual products tested at 25°C. This data is considered typical for the converter. Applies to Figure 7, Figure 8, and Figure 9.

The temperature derating curves represent the conditions at which internal components are at or below the manufacturer's maximum operating temperatures. Derating limits apply to devices soldered directly to a 100-mm × 100-mm double-sided PCB with 2-oz. copper. Applies to Figure 11.

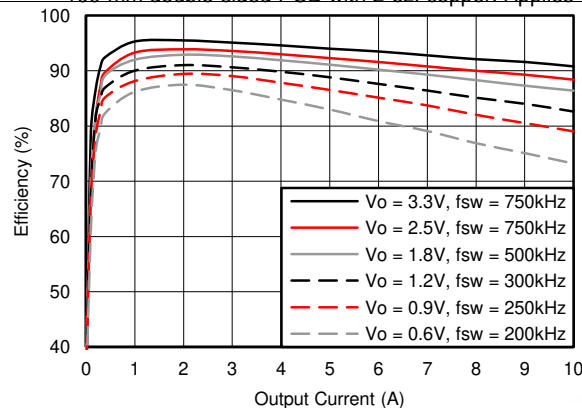


Figure 7. Efficiency versus Output Current

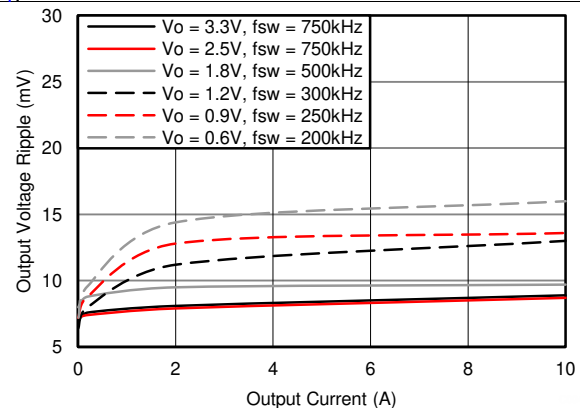


Figure 8. Voltage Ripple versus Output Current

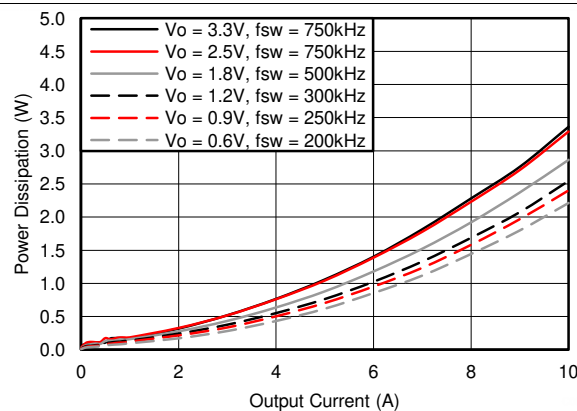


Figure 9. Power Dissipation versus Output Current

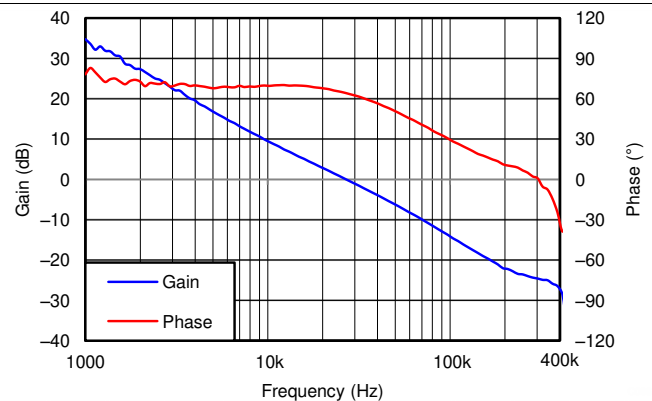


Figure 10.  $V_{OUT} = 1.8\text{ V}$ ,  $I_{OUT} = 10\text{ A}$ ,  $C_{OUT1} = 200\text{ }\mu\text{F}$  Ceramic,  $f_{sw} = 500\text{ kHz}$

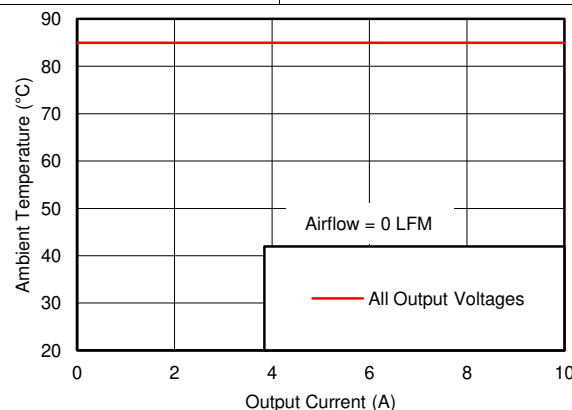


Figure 11. Safe Operating Area

## 9 Typical Characteristics (PVIN = 3.3 V, VIN = 5 V)

The electrical characteristic data has been developed from actual products tested at 25°C. This data is considered typical for the converter. Applies to Figure 12, Figure 13, and Figure 14.

The temperature derating curves represent the conditions at which internal components are at or below the

## Typical Characteristics (PVIN = 3.3 V, VIN = 5 V) (continued)

manufacturer's maximum operating temperatures. Derating limits apply to devices soldered directly to a 100 mm × 100 mm double-sided PCB with 2 oz. copper. Applies to Figure 16.

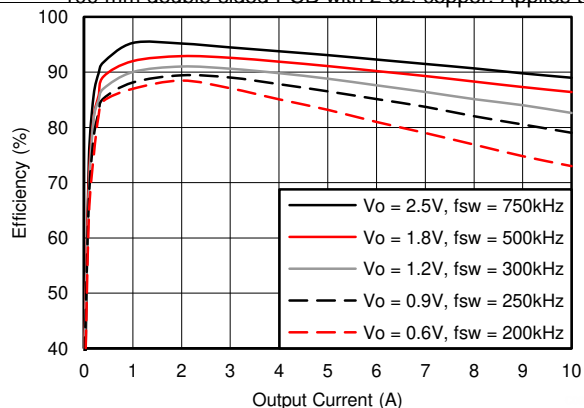


Figure 12. Efficiency versus Output Current

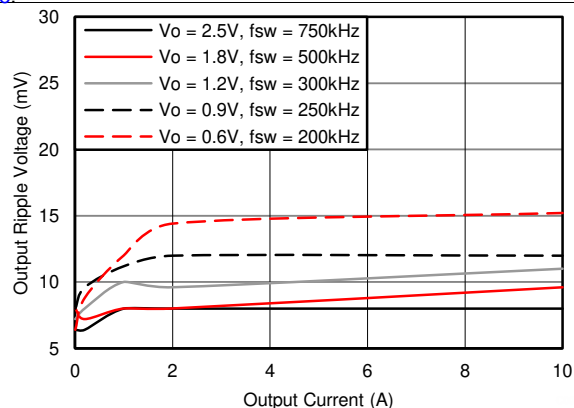


Figure 13. Voltage Ripple versus Output Current

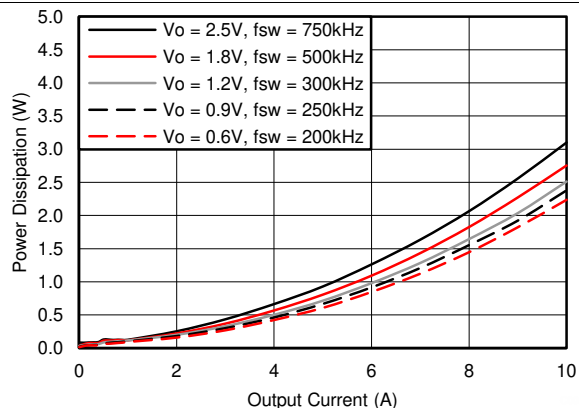


Figure 14. Power Dissipation versus Output Current

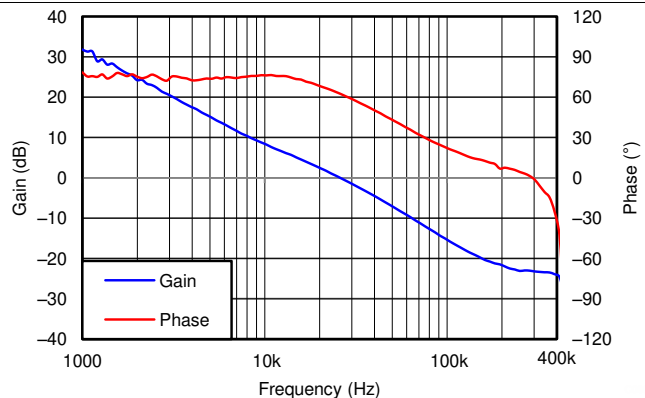


Figure 15.  $V_{OUT} = 1.8\text{ V}$ ,  $I_{OUT} = 10\text{ A}$ ,  $C_{OUT1} = 200\text{ }\mu\text{F}$  Ceramic,  $f_{sw} = 500\text{ kHz}$

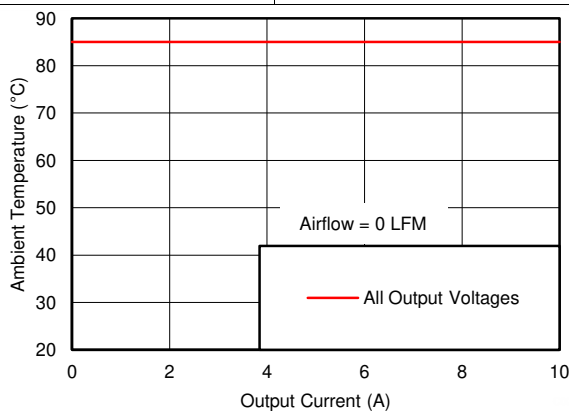


Figure 16. Safe Operating Area

## 10 Application Information

### 10.1 Adjusting the Output Voltage

The VADJ control sets the output voltage of the TPS84A20. The output voltage adjustment range is from 0.6 V to 5.5 V. The adjustment method requires the addition of  $R_{SET}$ , which sets the output voltage, the connection of SENSE+ to VOUT, and in some cases  $R_{RT}$  which sets the switching frequency. The  $R_{SET}$  resistor must be connected directly between the VADJ (pin 26) and AGND (pin 23). The SENSE+ pin (pin 27) must be connected to VOUT either at the load for improved regulation or at VOUT of the device. The  $R_{RT}$  resistor must be connected directly between the RT/CLK (pin 22) and AGND (pin 23). Table 3 gives the standard external  $R_{SET}$  resistor for a number of common bus voltages, along with the recommended  $R_{RT}$  resistor for that output voltage.

**Table 3. Standard  $R_{SET}$  Resistor Values for Common Output Voltages**

| RESISTORS               | OUTPUT VOLTAGE $V_{OUT}$ (V) |      |      |       |       |       |       |
|-------------------------|------------------------------|------|------|-------|-------|-------|-------|
|                         | 0.9                          | 1.0  | 1.2  | 1.8   | 2.5   | 3.3   | 5.0   |
| $R_{SET}$ (k $\Omega$ ) | 2.87                         | 2.15 | 1.43 | 0.715 | 0.453 | 0.316 | 0.196 |
| $R_{RT}$ (k $\Omega$ )  | 1000                         | 1000 | 487  | 169   | 90.9  | 90.9  | 63.4  |

For other output voltages, the value of the required resistor can either be calculated using the following formula, or simply selected from the range of values given in Table 4.

$$R_{SET} = \frac{1.43}{\left(\left(\frac{V_{OUT}}{0.6}\right) - 1\right)} \text{ (k}\Omega\text{)} \quad (1)$$

**Table 4. Standard  $R_{SET}$  Resistor Values**

| $V_{OUT}$ (V) | $R_{SET}$ (k $\Omega$ ) | $R_{RT}$ (k $\Omega$ ) | $f_{SW}$ (kHz) | $V_{OUT}$ (V) | $R_{SET}$ (k $\Omega$ ) | $R_{RT}$ (k $\Omega$ ) | $f_{SW}$ (kHz) |
|---------------|-------------------------|------------------------|----------------|---------------|-------------------------|------------------------|----------------|
| 0.6           | open                    | OPEN                   | 200            | 3.1           | 0.348                   | 90.9                   | 750            |
| 0.7           | 8.66                    | OPEN                   | 200            | 3.2           | 0.332                   | 90.9                   | 750            |
| 0.8           | 4.32                    | OPEN                   | 200            | 3.3           | 0.316                   | 90.9                   | 750            |
| 0.9           | 2.87                    | 1000                   | 250            | 3.4           | 0.309                   | 90.9                   | 750            |
| 1.0           | 2.15                    | 1000                   | 250            | 3.5           | 0.294                   | 90.9                   | 750            |
| 1.1           | 1.74                    | 1000                   | 250            | 3.6           | 0.287                   | 90.9                   | 750            |
| 1.2           | 1.43                    | 487                    | 300            | 3.7           | 0.280                   | 90.9                   | 750            |
| 1.3           | 1.24                    | 487                    | 300            | 3.8           | 0.267                   | 90.9                   | 750            |
| 1.4           | 1.07                    | 487                    | 300            | 3.9           | 0.261                   | 90.9                   | 750            |
| 1.5           | 0.953                   | 487                    | 300            | 4.0           | 0.255                   | 90.9                   | 750            |
| 1.6           | 0.866                   | 487                    | 300            | 4.1           | 0.243                   | 63.4                   | 1000           |
| 1.7           | 0.787                   | 487                    | 300            | 4.2           | 0.237                   | 63.4                   | 1000           |
| 1.8           | 0.715                   | 169                    | 500            | 4.3           | 0.232                   | 63.4                   | 1000           |
| 1.9           | 0.665                   | 169                    | 500            | 4.4           | 0.226                   | 63.4                   | 1000           |
| 2.0           | 0.619                   | 169                    | 500            | 4.5           | 0.221                   | 63.4                   | 1000           |
| 2.1           | 0.576                   | 169                    | 500            | 4.6           | 0.215                   | 63.4                   | 1000           |
| 2.2           | 0.536                   | 169                    | 500            | 4.7           | 0.210                   | 63.4                   | 1000           |
| 2.3           | 0.511                   | 169                    | 500            | 4.8           | 0.205                   | 63.4                   | 1000           |
| 2.4           | 0.475                   | 169                    | 500            | 4.9           | 0.200                   | 63.4                   | 1000           |
| 2.5           | 0.453                   | 90.9                   | 750            | 5.0           | 0.196                   | 63.4                   | 1000           |
| 2.6           | 0.432                   | 90.9                   | 750            | 5.1           | 0.191                   | 63.4                   | 1000           |
| 2.7           | 0.412                   | 90.9                   | 750            | 5.2           | 0.187                   | 63.4                   | 1000           |
| 2.8           | 0.392                   | 90.9                   | 750            | 5.3           | 0.182                   | 63.4                   | 1000           |
| 2.9           | 0.374                   | 90.9                   | 750            | 5.4           | 0.178                   | 63.4                   | 1000           |
| 3.0           | 0.357                   | 90.9                   | 750            | 5.5           | 0.174                   | 63.4                   | 1000           |

## 10.2 Capacitor Recommendations for the TPS84A20 Power Supply

### 10.2.1 Capacitor Technologies

#### 10.2.1.1 Electrolytic, Polymer-Electrolytic Capacitors

When using electrolytic capacitors, high-quality, computer-grade electrolytic capacitors are recommended. Polymer-electrolytic type capacitors are recommended for applications where the ambient operating temperature is less than 0°C. The Sanyo OS-CON capacitor series is suggested due to the lower ESR, higher rated surge, power dissipation, ripple current capability, and small package size. Aluminum electrolytic capacitors provide adequate decoupling over the frequency range of 2 kHz to 150 kHz, and are suitable when ambient temperatures are above 0°C.

#### 10.2.1.2 Ceramic Capacitors

The performance of aluminum electrolytic capacitors is less effective than ceramic capacitors above 150 kHz. Multilayer ceramic capacitors have a low ESR and a resonant frequency higher than the bandwidth of the regulator. They can be used to reduce the reflected ripple current at the input as well as improve the transient response of the output.

#### 10.2.1.3 Tantalum, Polymer-Tantalum Capacitors

Polymer-tantalum type capacitors are recommended for applications where the ambient operating temperature is less than 0°C. The Sanyo POSCAP series and Kemet T530 capacitor series are recommended rather than many other tantalum types due to their lower ESR, higher rated surge, power dissipation, ripple current capability, and small package size. Tantalum capacitors that have no stated ESR or surge current rating are not recommended for power applications.

### 10.2.2 Input Capacitor

The TPS84A20 requires a minimum input capacitance of 44  $\mu\text{F}$  of ceramic type. An additional 100  $\mu\text{F}$  of non-ceramic capacitance is recommended for applications with transient load requirements. The voltage rating of input capacitors must be greater than the maximum input voltage. At worst case, when operating at 50% duty cycle and maximum load, the combined ripple current rating of the input capacitors must be at least 5 Arms. [Table 6](#) includes a preferred list of capacitors by vendor. It is also recommended to place a 0.1- $\mu\text{F}$  ceramic capacitor directly across the PVIN and PGND pins of the device. When operating with split VIN and PVIN rails, place 4.7  $\mu\text{F}$  of ceramic capacitance directly at the VIN pin.

### 10.2.3 Output Capacitor

The required output capacitance is determined by the output voltage of the TPS84A20. See [Table 5](#) for the amount of required capacitance. The effects of temperature and capacitor voltage rating must be considered when selecting capacitors to meet the minimum required capacitance. The required output capacitance can be comprised of all ceramic capacitors, or a combination of ceramic and bulk capacitors. The required capacitance must include at least one 47  $\mu\text{F}$  ceramic. When adding additional non-ceramic bulk capacitors, low-ESR devices like the ones recommended in [Table 6](#) are required. The required capacitance above the minimum is determined by actual transient deviation requirements. See [Table 7](#) for typical transient response values for several output voltage, input voltage and capacitance combinations. [Table 6](#) includes a preferred list of capacitors by vendor.

**Table 5. Required Output Capacitance**

| V <sub>OUT</sub> RANGE (V) |       | MINIMUM REQUIRED C <sub>OUT</sub> ( $\mu\text{F}$ ) |
|----------------------------|-------|---|
| MIN                        | MAX   |   |
| 0.6                        | < 0.8 | 500 $\mu\text{F}$ <sup>(1)</sup>                    |
| 0.8                        | < 1.2 | 300 $\mu\text{F}$ <sup>(1)</sup>                    |
| 1.2                        | < 3.0 | 200 $\mu\text{F}$ <sup>(1)</sup>                    |
| 3.0                        | < 4.0 | 100 $\mu\text{F}$ <sup>(1)</sup>                    |
| 4.0                        | 5.5   | 47 $\mu\text{F}$ ceramic                            |

(1) Minimum required must include at least one 47- $\mu\text{F}$  ceramic capacitor.

**Table 6. Recommended Input/Output Capacitors<sup>(1)</sup>**

| VENDOR    | SERIES | PART NUMBER        | CAPACITOR CHARACTERISTICS |                  |                         |
|-----------|--------|--------------------|---------------------------|------------------|-------------------------|
|           |        |                    | WORKING VOLTAGE (V)       | CAPACITANCE (μF) | ESR <sup>(2)</sup> (mΩ) |
| Murata    | X5R    | GRM32ER61E226K     | 25                        | 22               | 2                       |
| TDK       | X5R    | C3225X5R0J107M     | 6.3                       | 100              | 2                       |
| TDK       | X5R    | C3225X5R0J476K     | 6.3                       | 47               | 2                       |
| Murata    | X5R    | GRM32ER60J107M     | 6.3                       | 100              | 2                       |
| Murata    | X5R    | GRM32ER60J476M     | 6.3                       | 47               | 2                       |
| Panasonic | EEH-ZA | EEH-ZA1E101XP      | 25                        | 100              | 30                      |
| Sanyo     | POSCAP | 16TQC68M           | 16                        | 68               | 50                      |
| Kemet     | T520   | T520V107M010ASE025 | 10                        | 100              | 25                      |
| Sanyo     | POSCAP | 10TPE220ML         | 10                        | 220              | 25                      |
| Sanyo     | POSCAP | 6TPE100MI          | 6.3                       | 100              | 25                      |
| Sanyo     | POSCAP | 2R5TPE220M7        | 2.5                       | 220              | 7                       |
| Kemet     | T530   | T530D227M006ATE006 | 6.3                       | 220              | 6                       |
| Kemet     | T530   | T530D337M006ATE010 | 6.3                       | 330              | 10                      |
| Sanyo     | POSCAP | 2TPF330M6          | 2.0                       | 330              | 6                       |
| Sanyo     | POSCAP | 6TPE330MFL         | 6.3                       | 330              | 15                      |

- (1) **Capacitor Supplier Verification, RoHS, Lead-free, and Material Details**  
Consult capacitor suppliers regarding availability, material composition, RoHS and lead-free status, and manufacturing process requirements for any capacitors identified in this table.
- (2) Maximum ESR at 100 kHz, 25°C.

## 10.3 Transient Response

**Table 7. Output Voltage Transient Response**

| C <sub>IN1</sub> = 3x 47 μF CERAMIC, C <sub>IN2</sub> = 100 μF POLYMER-TANTALUM |                     |                           |                        |                           |                         |                    |
|---|---------------------|---------------------------|------------------------|---------------------------|-------------------------|--------------------|
| V <sub>OUT</sub> (V)  | V <sub>IN</sub> (V) | C <sub>OUT1</sub> CERAMIC | C <sub>OUT2</sub> BULK | VOLTAGE DEVIATION (mV)    |                         | RECOVERY TIME (μs) |
|   |                     |                           |                        | 2.5 A LOAD STEP, (1 A/μs) | 5 A LOAD STEP, (1 A/μs) |                    |
| 0.6   | 5                   | 500 μF                    | 220 μF                 | 25                        | 60                      | 100                |
|   | 12                  | 500 μF                    | 220 μF                 | 30                        | 65                      | 100                |
| 0.9   | 5                   | 300 μF                    | 220 μF                 | 40                        | 85                      | 100                |
|   |                     | 300 μF                    | 470 μF                 | 35                        | 70                      | 110                |
|   | 12                  | 300 μF                    | 220 μF                 | 45                        | 90                      | 100                |
|   |                     | 300 μF                    | 470 μF                 | 35                        | 75                      | 110                |
| 1.2   | 5                   | 200 μF                    | 220 μF                 | 55                        | 110                     | 110                |
|   |                     | 200 μF                    | 470 μF                 | 45                        | 90                      | 110                |
|   | 12                  | 200 μF                    | 220 μF                 | 55                        | 110                     | 110                |
|   |                     | 200 μF                    | 470 μF                 | 45                        | 90                      | 110                |
| 1.8   | 5                   | 200 μF                    | 220 μF                 | 70                        | 140                     | 130                |
|   |                     | 200 μF                    | 470 μF                 | 60                        | 120                     | 140                |
|   | 12                  | 200 μF                    | 220 μF                 | 70                        | 145                     | 140                |
|   |                     | 200 μF                    | 470 μF                 | 55                        | 120                     | 150                |
| 3.3   | 5                   | 100 μF                    | 220 μF                 | 115                       | 230                     | 200                |
|   | 12                  | 100 μF                    | 220 μF                 | 120                       | 240                     | 200                |

## 10.4 Transient Waveforms

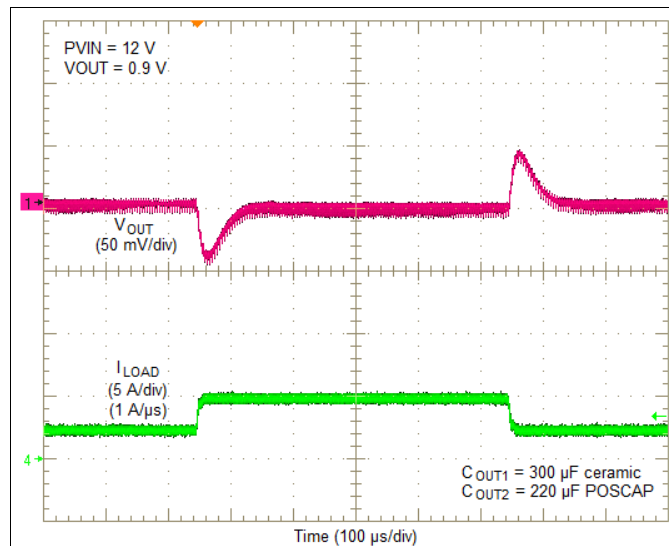


Figure 17. PVIN = 12 V, VOUT = 0.9 V, 2.5 A Load Step

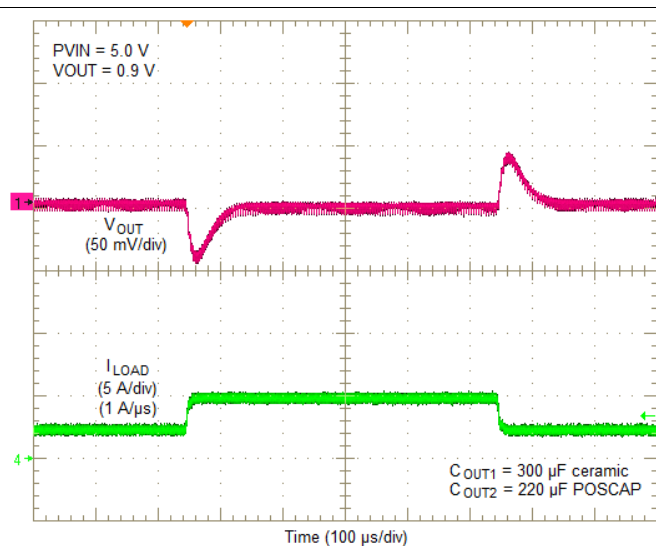


Figure 18. PVIN = 5 V, VOUT = 0.9 V, 2.5 A Load Step

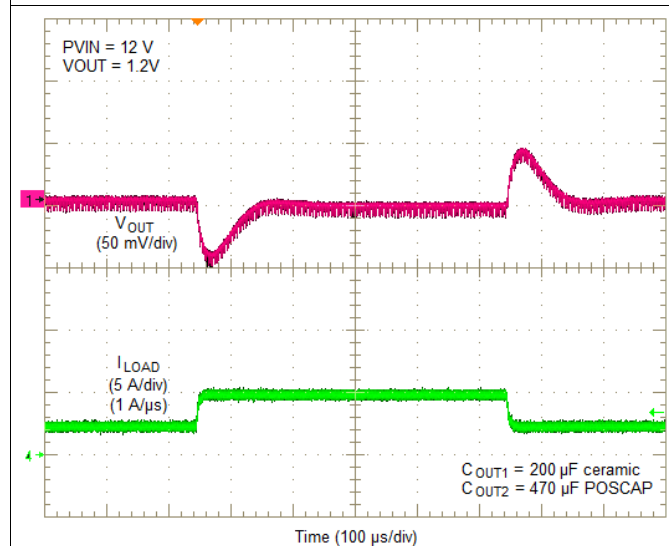


Figure 19. PVIN = 12 V, VOUT = 1.2 V, 2.5 A Load Step

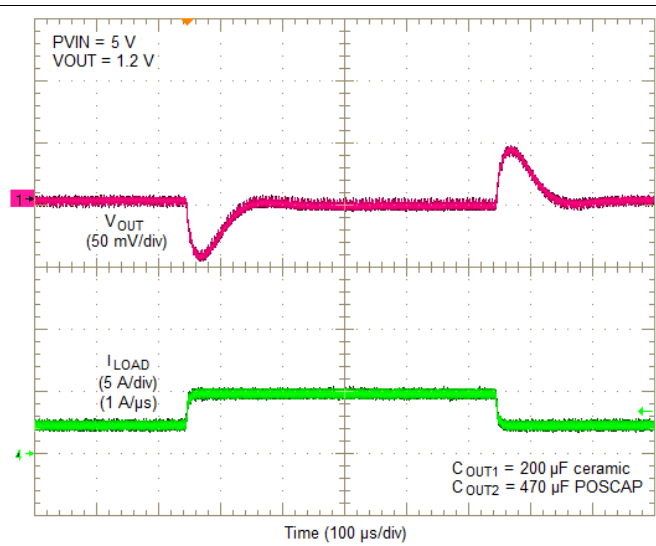
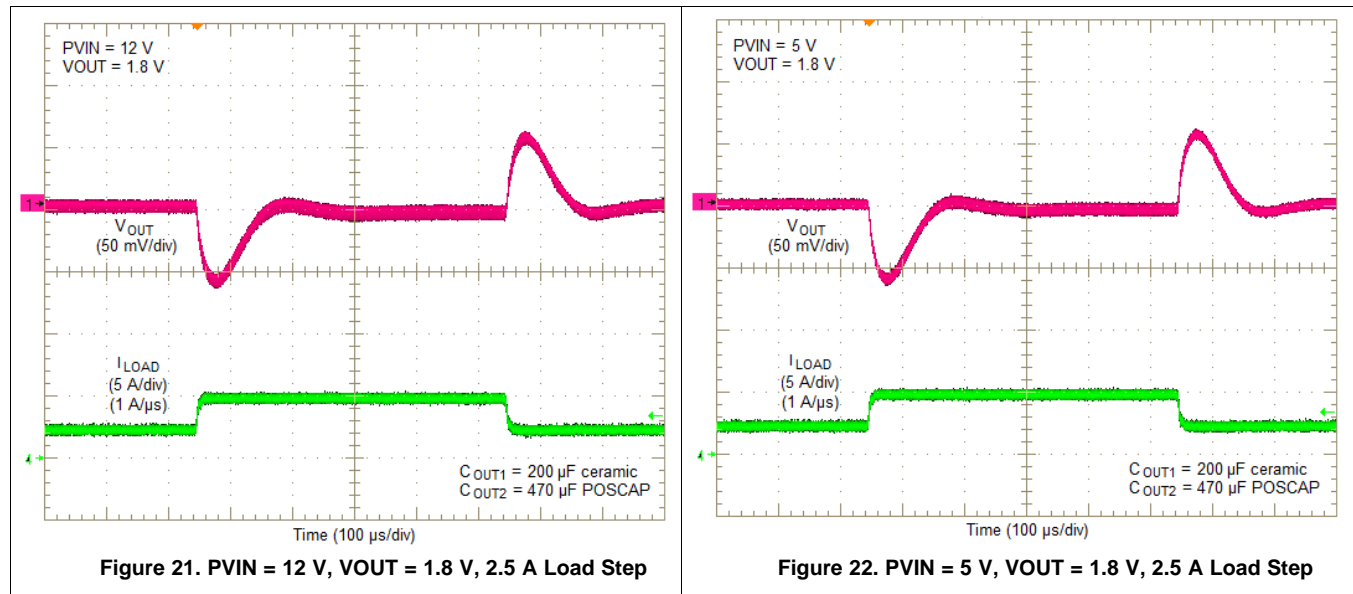
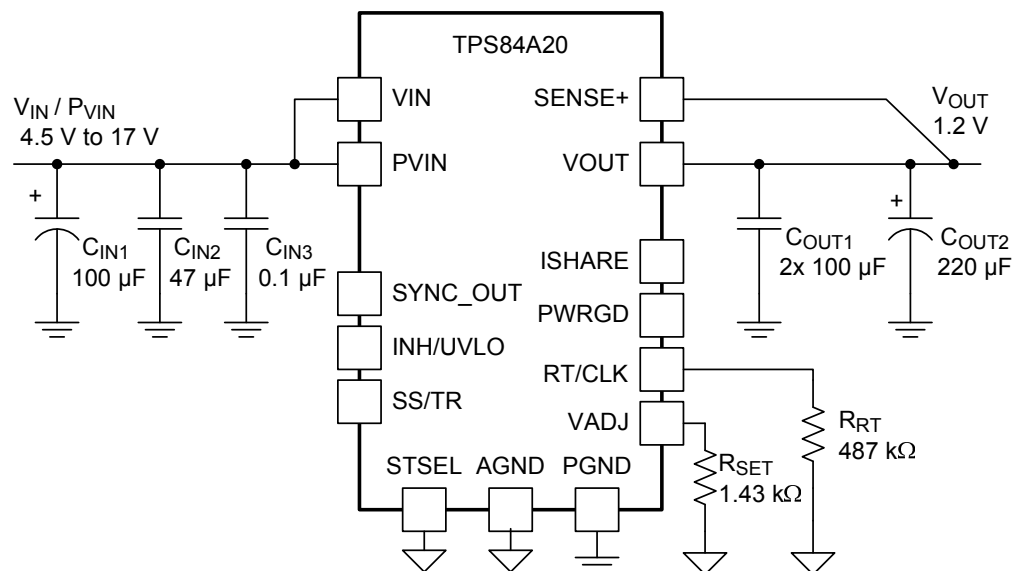


Figure 20. PVIN = 5 V, VOUT = 1.2 V, 2.5 A Load Step

## Transient Waveforms (continued)



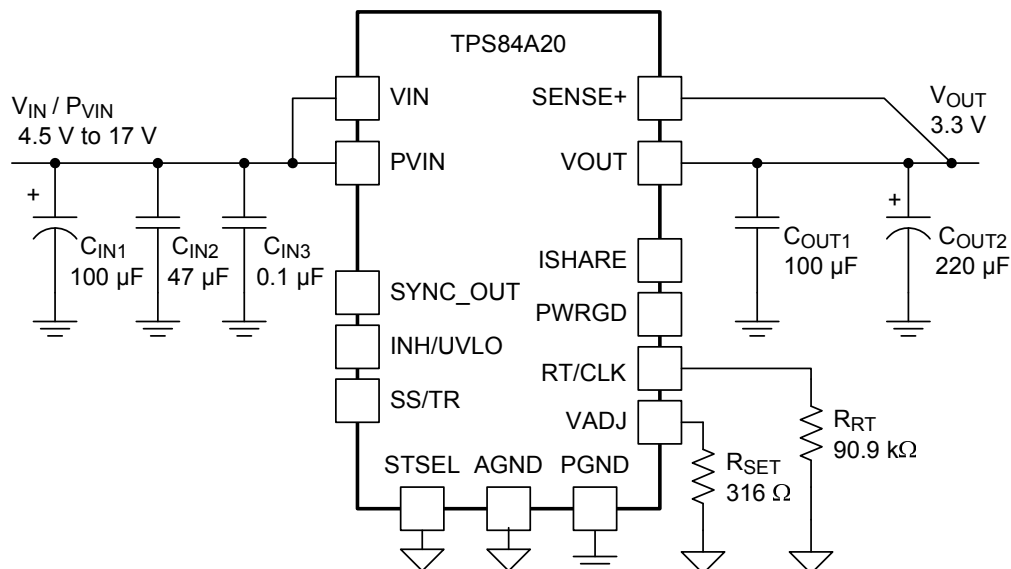
## 10.5 Application Schematics



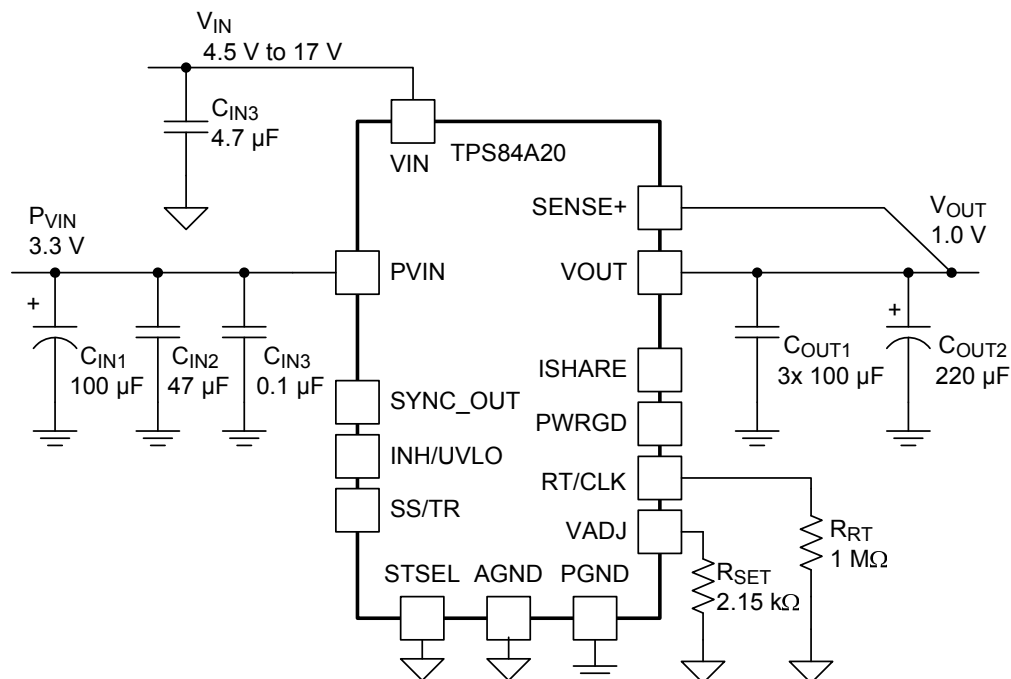
**Figure 23. Typical Schematic**  
 $P_{VIN} = V_{IN} = 4.5$  V to 17 V,  $V_{OUT} = 1.2$  V



## Application Schematics (continued)



**Figure 24. Typical Schematic**  
P\_VIN = V\_IN = 4.5 V to 17 V, V\_OUT = 3.3 V



**Figure 25. Typical Schematic**  
P\_VIN = 3.3 V, V\_IN = 4.5 V to 17 V, V\_OUT = 1.0 V

## 10.6 VIN and PVIN Input Voltage

The TPS84A20 allows for a variety of applications by using the VIN and PVIN pins together or separately. The VIN voltage supplies the internal control circuits of the device. The PVIN voltage provides the input voltage to the power converter system.

If tied together, the input voltage for the VIN pin and the PVIN pin can range from 4.5 V to 17 V. If you are using the VIN pin separately from the PVIN pin, the VIN pin must be greater than 4.5 V, and the PVIN pin can range from as low as 2.95 V to 17 V. When operating from a split rail, it is recommended to supply VIN from 5 V to 12 V, for best performance. A voltage divider connected to the INH/UVLO pin can adjust either input voltage UVLO appropriately. See the [Programmable Undervoltage Lockout \(UVLO\)](#) section for more information.

## 10.7 3.3 V PVIN Operation

Applications operating from a PVIN of 3.3 V must provide at least 4.5 V for VIN. It is recommended to supply VIN from 5 V to 12 V, for best performance. See the [Powering TPS84k Devices from 3.3 V Application Note](#) for help creating 5 V from 3.3 V using a small, simple charge pump device.

## 10.8 Power Good (PWRGD)

The PWRGD pin is an open-drain output. Once the voltage on the SENSE+ pin is between 95% and 104% of the set voltage, the PWRGD pin pulldown is released and the pin floats. The recommended pullup resistor value is between 10 kΩ and 100 kΩ to a voltage source that is 5.5 V or less. The PWRGD pin is in a defined state once VIN is greater than 1.0 V, but with reduced current sinking capability. The PWRGD pin achieves full current sinking capability once the VIN pin is above 4.5 V. The PWRGD pin is pulled low when the voltage on SENSE+ is lower than 91% or greater than 108% of the nominal set voltage. Also, the PWRGD pin is pulled low if the input UVLO or thermal shutdown is asserted, the INH pin is pulled low, or the SS/TR pin is below 1.4 V.

## 10.9 Light Load Efficiency (LLE)

The TPS84A20 operates in pulse skip mode at light load currents to improve efficiency and decrease power dissipation by reducing switching and gate drive losses.

These pulses can cause the output voltage to rise when there is no load to discharge the energy. For output voltages < 1.5 V, a minimum load is required. The amount of required load can be determined by [Equation 2](#). In most cases, the minimum current drawn by the load circuit will be enough to satisfy this load. Applications requiring a load resistor to meet the minimum load, the added power dissipation will be ≤ 3.6 mW. A single 0402 size resistor across VOUT and PGND can be used.

$$I_{\text{MIN}} = 600 \mu\text{A} - \left( \frac{V_{\text{OUT}}}{1.43\text{k} + R_{\text{SET}}} \right) (\text{A}) \quad (2)$$

When  $V_{\text{OUT}} = 0.6 \text{ V}$  and  $R_{\text{SET}} = \text{OPEN}$ , the minimum load current is 600 μA.

## 10.10 SYNC\_OUT

The TPS84A20 provides a 180° out-of-phase clock signal for applications requiring synchronization. The SYNC\_OUT pin produces a 50% duty cycle clock signal that is the same frequency as the switching frequency of the device, but is 180° out of phase. Operating two devices 180° out of phase reduces input and output voltage ripple. The SYNC\_OUT clock signal is compatible with other TPS84K devices that have a CLK input.

## 10.11 Parallel Operation

Up to six TPS84A20 devices can be paralleled for increased output current. Multiple connections must be made between the paralleled devices and the component selection is slightly different than for a stand-alone TPS84A20 device. [Figure 26](#) shows a typical TPS84A20 parallel schematic. Refer to the [TPS84A20 Parallel Operation Application Note](#) for information and design help when paralleling multiple TPS84A20 devices.

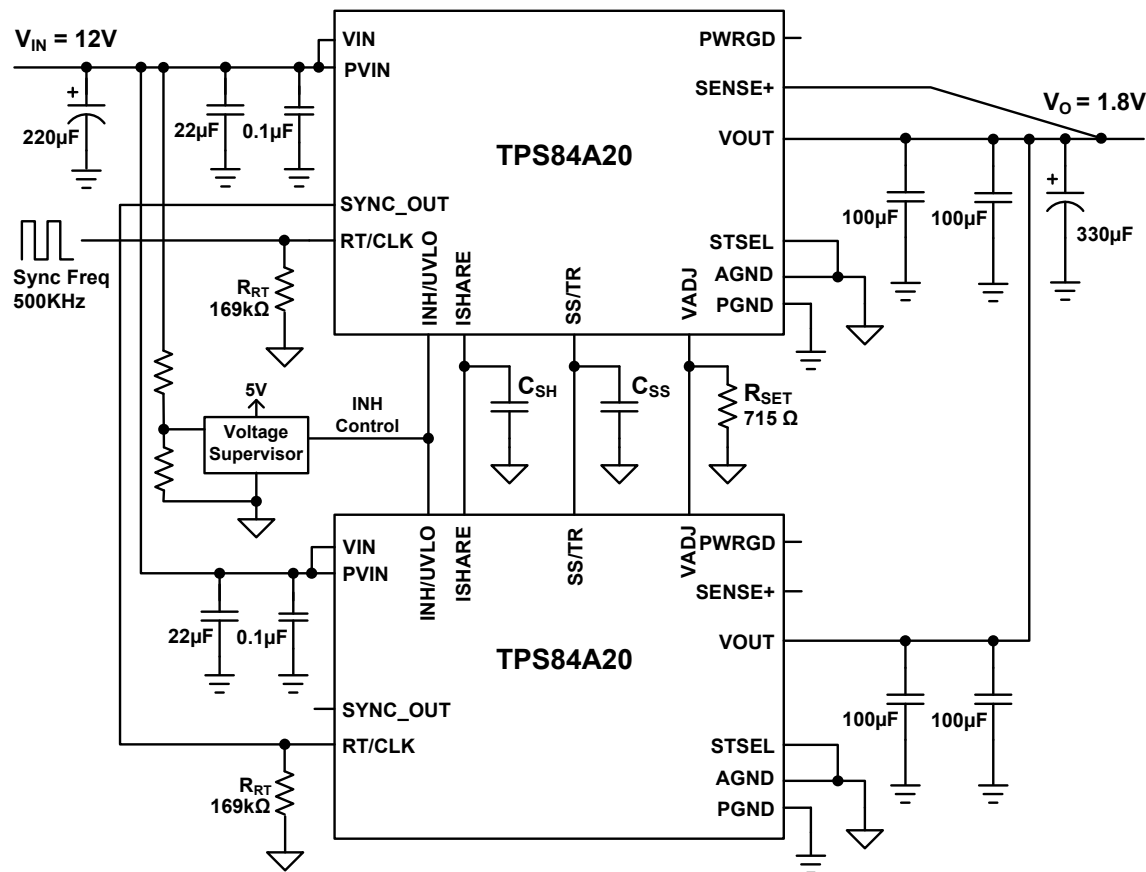
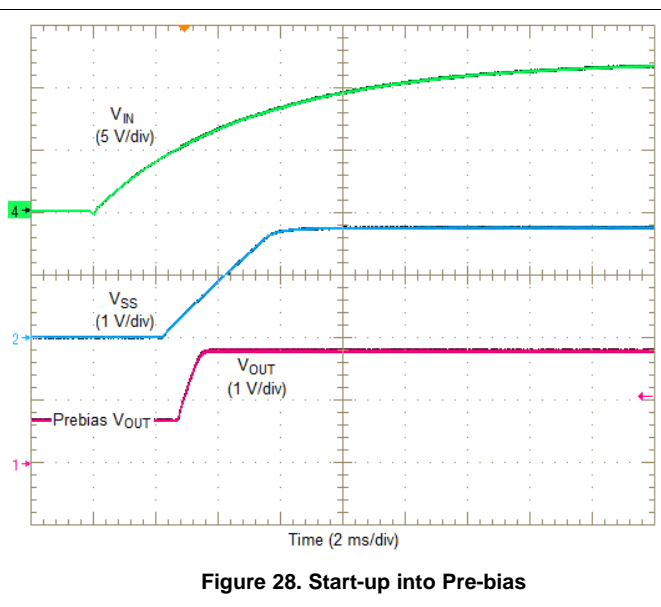
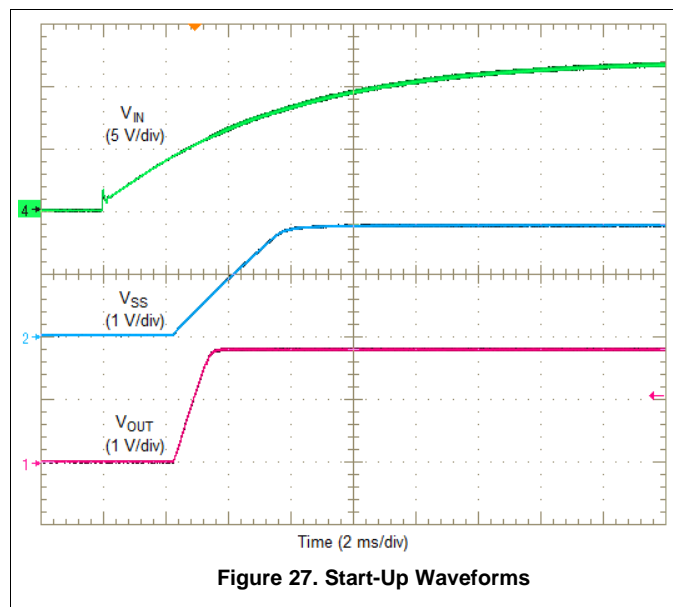


Figure 26. Typical TPS84A20 Parallel Schematic

## 10.12 Power-Up Characteristics

When configured as shown in the front page schematic, the TPS84A20 produces a regulated output voltage following the application of a valid input voltage. During the power-up, internal soft-start circuitry slows the rate that the output voltage rises, thereby limiting the amount of in-rush current that can be drawn from the input source. [Figure 27](#) shows the start-up waveforms for a TPS84A20, operating from a 5-V input ( $P_{VIN} = V_{IN}$ ) and with the output voltage adjusted to 1.8 V. [Figure 28](#) shows the start-up waveforms for a TPS84A20 starting up into a pre-biased output voltage. The waveforms were measured with a 5-A constant current load.



## 10.13 Pre-Biased Start-Up

The TPS84A20 has been designed to prevent the low-side MOSFET from discharging a pre-biased output. During pre-biased startup, the low-side MOSFET does not turn on until the high-side MOSFET has started switching. The high-side MOSFET does not start switching until the slow start voltage exceeds the voltage on the VADJ pin. Refer to [Figure 28](#).

## 10.14 Remote Sense

The SENSE+ pin must be connected to  $V_{OUT}$  at the load, or at the device pins.

Connecting the SENSE+ pin to  $V_{OUT}$  at the load improves the load regulation performance of the device by allowing it to compensate for any I-R voltage drop between its output pins and the load. An I-R drop is caused by the high output current flowing through the small amount of pin and trace resistance. This should be limited to a maximum of 300 mV.

### NOTE

The remote sense feature is not designed to compensate for the forward drop of nonlinear or frequency dependent components that can be placed in series with the converter output. Examples include OR-ing diodes, filter inductors, ferrite beads, and fuses. When these components are enclosed by the SENSE+ connection, they are effectively placed inside the regulation control loop, which can adversely affect the stability of the regulator.

## 10.15 Thermal Shutdown

The internal thermal shutdown circuitry forces the device to stop switching if the junction temperature exceeds 175°C typically. The device reinitiates the power-up sequence when the junction temperature drops below 165°C typically.

## 10.16 Output On/Off Inhibit (INH)

The INH pin provides electrical on/off control of the device. Once the INH pin voltage exceeds the threshold voltage, the device starts operation. If the INH pin voltage is pulled below the threshold voltage, the regulator stops switching and enters low quiescent current state.

The INH pin has an internal pullup current source, allowing the user to float the INH pin for enabling the device. If an application requires controlling the INH pin, use an open drain/collector device, or a suitable logic gate to interface with the pin.

Figure 29 shows the typical application of the inhibit function. The Inhibit control has its own internal pullup to VIN potential. An open-collector or open-drain device is recommended to control this input.

Turning Q1 on applies a low voltage to the inhibit control (INH) pin and disables the output of the supply, shown in Figure 30. If Q1 is turned off, the supply executes a soft-start power-up sequence, as shown in Figure 31. A regulated output voltage is produced within 2 ms. The waveforms were measured with a 5-A constant current load.

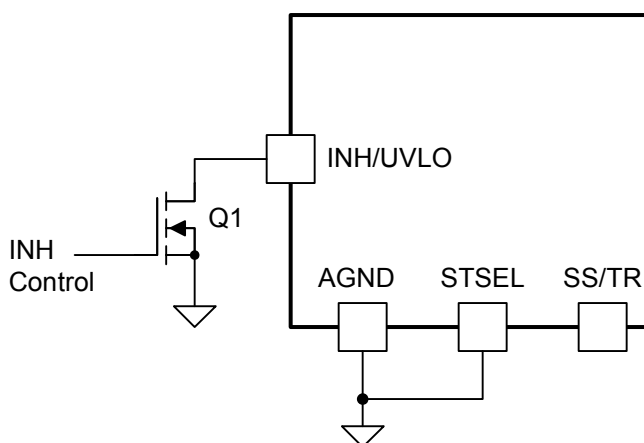
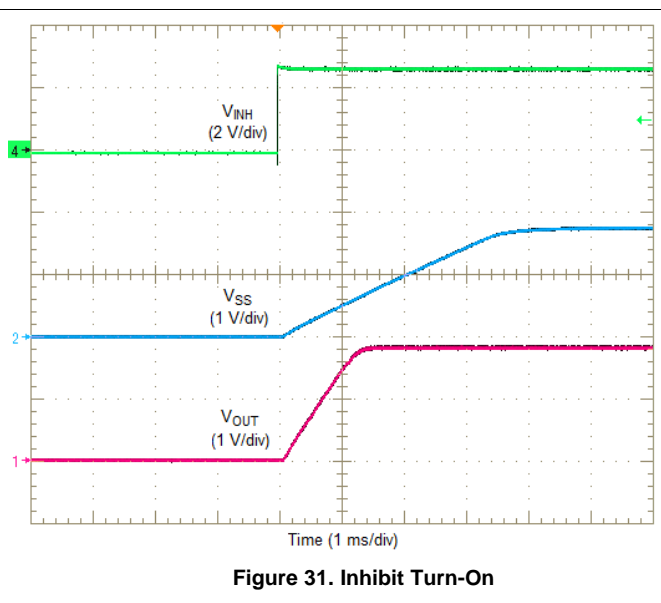
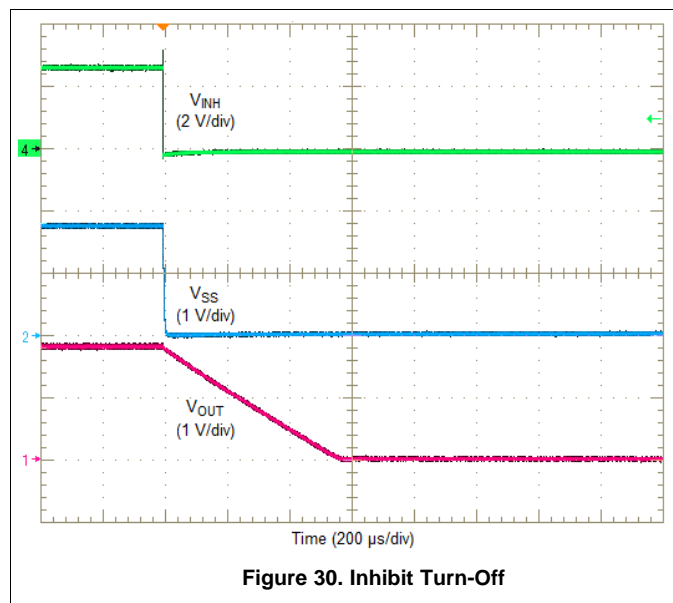
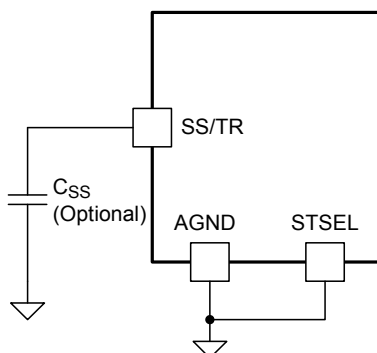


Figure 29. Typical Inhibit Control



## 10.17 Slow Start (SS/TR)

Connecting the STSEL pin to AGND and leaving SS/TR pin open enables the internal SS capacitor with a slow start interval of approximately 1.2 ms. Adding additional capacitance between the SS pin and AGND increases the slow start time. Increasing the slow start time reduces inrush current. [Table 8](#) shows an additional SS capacitor connected to the SS/TR pin and the STSEL pin connected to AGND. See [Table 8](#) for SS capacitor values and timing interval.



**Figure 32. Slow-Start Capacitor ( $C_{SS}$ ) and STSEL Connection**

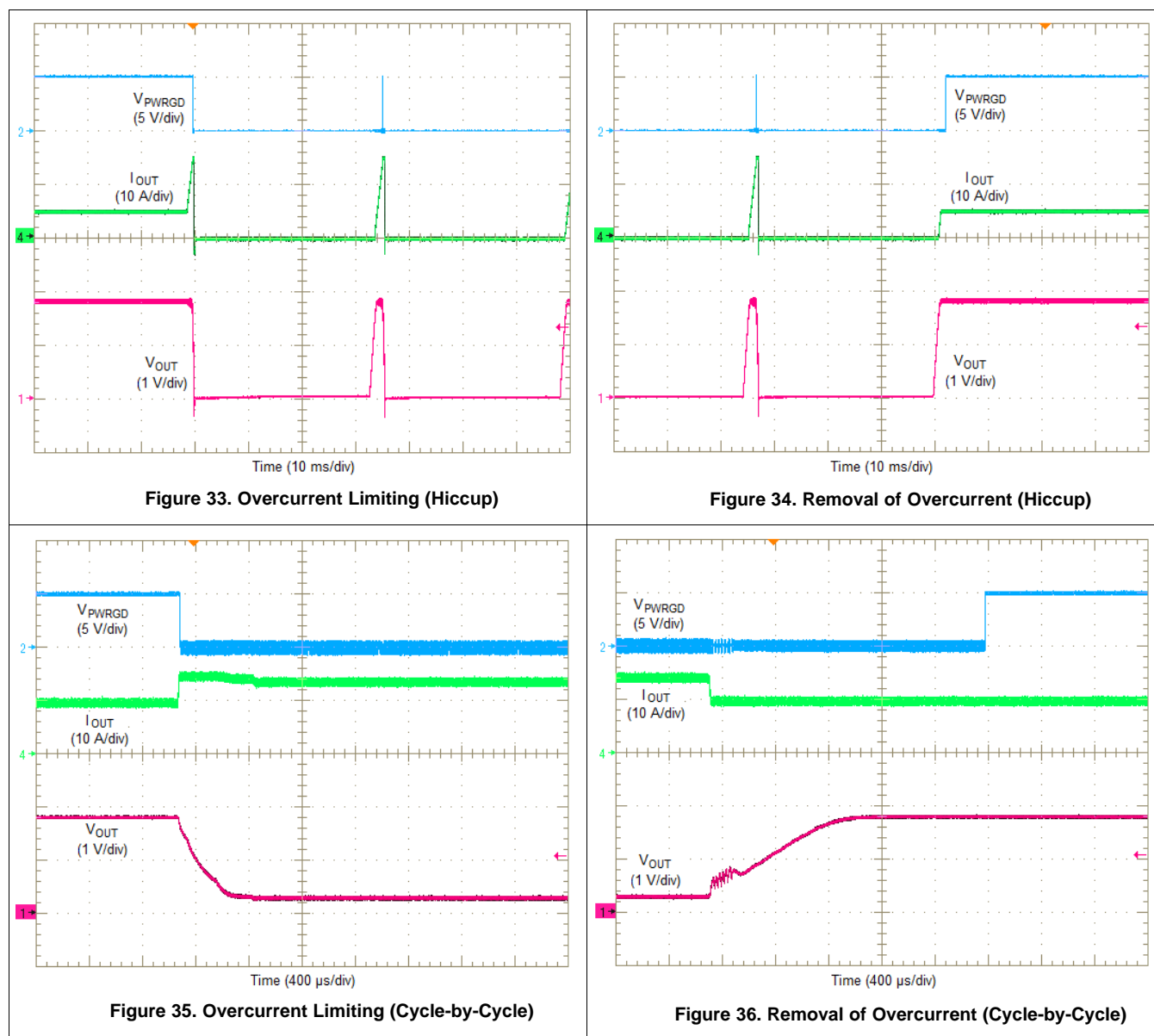
**Table 8. Slow-Start Capacitor Values and Slow-Start Time**

| $C_{SS}$ (nF)  | OPEN | 3.3 | 4.7 | 10  | 15  | 22  | 33  |
|----------------|------|-----|-----|-----|-----|-----|-----|
| SS Time (msec) | 1.2  | 2.1 | 2.5 | 3.8 | 5.1 | 7.0 | 9.8 |

## 10.18 Overcurrent Protection

For protection against load faults, the TPS84A20 incorporates output overcurrent protection. The overcurrent protection mode can be selected using the OCP\_SEL pin. Leaving the OCP\_SEL pin open selects hiccup mode and connecting it to AGND selects cycle-by-cycle mode. In hiccup mode, applying a load that exceeds the overcurrent threshold of the regulator causes the regulated output to shut down. Following shutdown, the module periodically attempts to recover by initiating a soft-start power-up as shown in Figure 33. This is described as a hiccup mode of operation, whereby the module continues in a cycle of successive shutdown and power up until the load fault is removed. During this period, the average current flowing into the fault is significantly reduced which reduces power dissipation. Once the fault is removed, the module automatically recovers and returns to normal operation as shown in Figure 34.

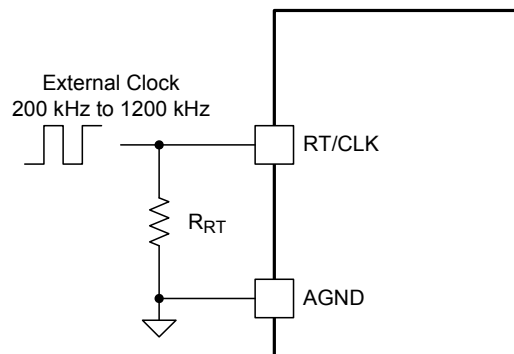
In cycle-by-cycle mode, applying a load that exceeds the overcurrent threshold of the regulator limits the output current and reduces the output voltage as shown in Figure 35. During this period, the current flowing into the fault remains high causing the power dissipation to stay high as well. Once the overcurrent condition is removed, the output voltage returns to the set-point voltage as shown in Figure 36.



## 10.19 Synchronization (CLK)

An internal phase locked loop (PLL) has been implemented to allow synchronization between 200 kHz and 1200 kHz, and to easily switch from RT mode to CLK mode. To implement the synchronization feature, connect a square wave clock signal to the RT/CLK pin with a duty cycle between 20% to 80%. The clock signal amplitude must transition lower than 0.5 V and higher than 2.0 V. The start of the switching cycle is synchronized to the falling edge of RT/CLK pin. In applications where both RT mode and CLK mode are needed, the device can be configured as shown in Figure 37.

Before the external clock is present, the device works in RT mode and the switching frequency is set by RT resistor. When the external clock is present, the CLK mode overrides the RT mode. The first time the CLK pin is pulled above the RT/CLK high threshold (2.0 V), the device switches from RT mode to CLK mode and the RT/CLK pin becomes high impedance as the PLL starts to lock onto the frequency of the external clock. It is not recommended to switch from CLK mode back to RT mode because the internal switching frequency drops to 100 kHz first before returning to the switching frequency set by the RT resistor ( $R_{RT}$ ).



**Figure 37. RT/CLK Configuration**

The switching frequency must be selected based on the output voltages of the devices being synchronized. Table 9 shows the allowable frequencies for a given range of output voltages. The allowable switching frequency changes based on the maximum output current ( $I_{OUT}$ ) of an application. The table shows the  $V_{OUT}$  range when  $I_{OUT} \leq 10$  A, 9 A, and 8 A. For the most efficient solution, always synchronize to the lowest allowable frequency. For example, an application requires synchronizing three TPS84A20 devices with output voltages of 1.0 V, 1.2 V and 1.8 V, all powered from  $P_{VIN} = 12$  V. Table 9 shows that all three output voltages should be synchronized to 300 kHz.

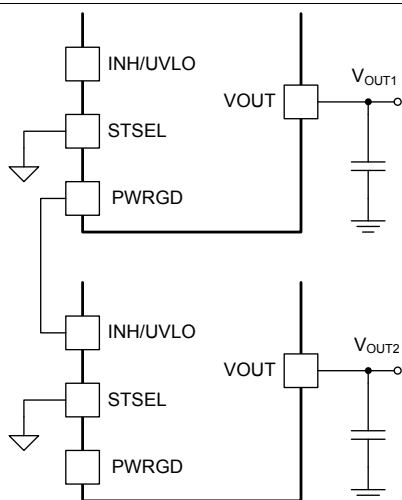
**Table 9. Allowable Switching Frequency versus Output Voltage**

| SWITCHING<br>FREQUENCY<br>(kHz) | P <sub>VIN</sub> = 12 V    |                        |                        | P <sub>VIN</sub> = 5 V     |                        |                        |
|---------------------------------|----------------------------|------------------------|------------------------|----------------------------|------------------------|------------------------|
|                                 | V <sub>OUT</sub> RANGE (V) |                        |                        | V <sub>OUT</sub> RANGE (V) |                        |                        |
|                                 | I <sub>OUT</sub> ≤ 10 A    | I <sub>OUT</sub> ≤ 9 A | I <sub>OUT</sub> ≤ 8 A | I <sub>OUT</sub> ≤ 10 A    | I <sub>OUT</sub> ≤ 9 A | I <sub>OUT</sub> ≤ 8 A |
| 200                             | 0.6 - 1.2                  | 0.6 - 1.6              | 0.6 - 2.0              | 0.6 - 1.5                  | 0.6 - 2.5              | 0.6 - 4.3              |
| 300                             | 0.8 - 1.9                  | 0.8 - 2.6              | 0.8 - 3.5              | 0.6 - 4.3                  | 0.6 - 4.3              | 0.6 - 4.3              |
| 400                             | 1.0 - 2.7                  | 1.0 - 4.0              | 1.0 - 5.5              | 0.6 - 4.3                  | 0.6 - 4.3              | 0.6 - 4.3              |
| 500                             | 1.3 - 3.8                  | 1.3 - 5.5              | 1.3 - 5.5              | 0.6 - 4.3                  | 0.6 - 4.3              | 0.6 - 4.3              |
| 600                             | 1.5 - 5.5                  | 1.5 - 5.5              | 1.5 - 5.5              | 0.7 - 4.3                  | 0.7 - 4.3              | 0.7 - 4.3              |
| 700                             | 1.8 - 5.5                  | 1.8 - 5.5              | 1.8 - 5.5              | 0.8 - 4.3                  | 0.8 - 4.3              | 0.8 - 4.3              |
| 800                             | 2.0 - 5.5                  | 2.0 - 5.5              | 2.0 - 5.5              | 0.9 - 4.3                  | 0.9 - 4.3              | 0.9 - 4.3              |
| 900                             | 2.2 - 5.5                  | 2.2 - 5.5              | 2.2 - 5.5              | 1.0 - 4.3                  | 1.0 - 4.3              | 1.0 - 4.3              |
| 1000                            | 2.5 - 5.5                  | 2.5 - 5.5              | 2.5 - 5.5              | 1.1 - 4.3                  | 1.1 - 4.3              | 1.1 - 4.3              |
| 1100                            | 2.7 - 5.5                  | 2.7 - 5.5              | 2.7 - 5.5              | 1.3 - 4.3                  | 1.2 - 4.3              | 1.2 - 4.3              |
| 1200                            | 3.0 - 5.5                  | 3.0 - 5.5              | 3.0 - 5.5              | 1.4 - 4.3                  | 1.3 - 4.3              | 1.3 - 4.3              |

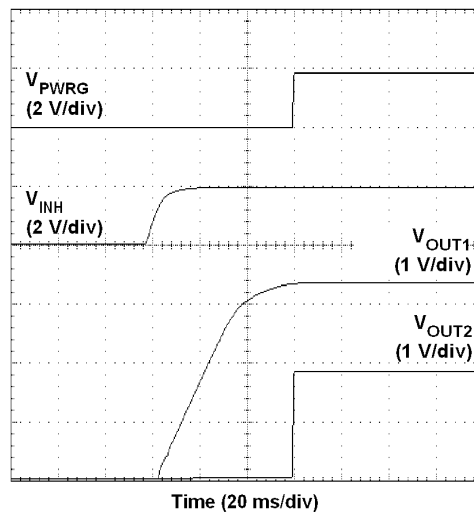


## 10.20 Sequencing (SS/TR)

Many of the common power supply sequencing methods can be implemented using the SS/TR, INH and PWRGD pins. The sequential method is illustrated in Figure 38 using two TPS84A20 devices. The PWRGD pin of the first device is coupled to the INH pin of the second device which enables the second power supply once the primary supply reaches regulation. Figure 39 shows sequential turnon waveforms of two TPS84A20 devices.



**Figure 38. Sequencing Schematic**



**Figure 39. Sequencing Waveforms**

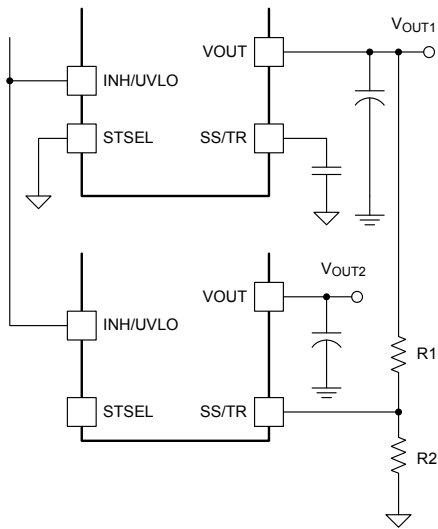
Simultaneous power supply sequencing can be implemented by connecting the resistor network of R1 and R2 shown in Figure 40 to the output of the power supply that needs to be tracked or to another voltage reference source. The tracking voltage must exceed 750 mV before  $V_{OUT2}$  reaches its set-point voltage. Figure 41 shows simultaneous turnon waveforms of two TPS84A20 devices. Use Equation 3 and Equation 4 to calculate the values of R1 and R2.

$$R1 = \frac{(V_{OUT2} \times 12.6)}{0.6} \text{ (k}\Omega\text{)}$$

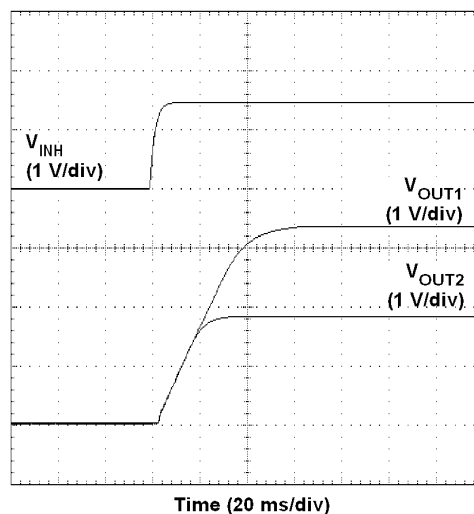
(3)

$$R2 = \frac{0.6 \times R1}{(V_{OUT2} - 0.6)} \text{ (k}\Omega\text{)}$$

(4)



**Figure 40. Simultaneous Tracking Schematic**

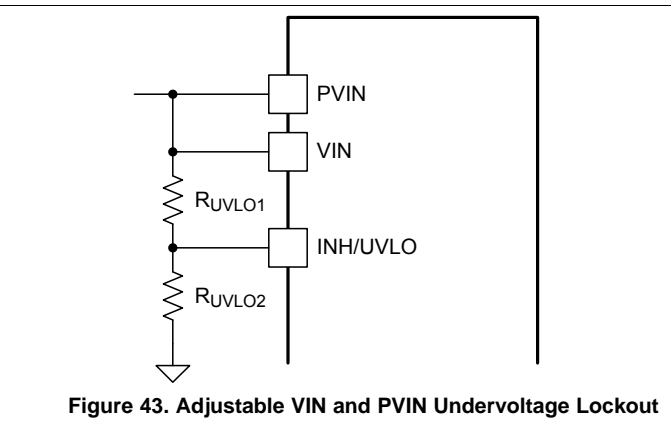
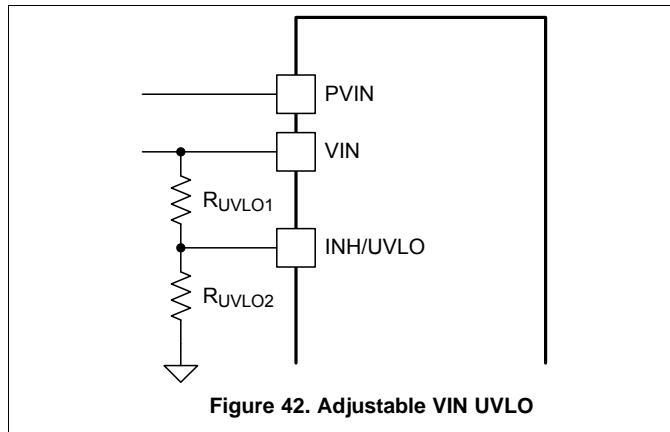


**Figure 41. Simultaneous Tracking Waveforms**

## 10.21 Programmable Undervoltage Lockout (UVLO)

The TPS84A20 implements internal UVLO circuitry on the VIN pin. The device is disabled when the VIN pin voltage falls below the internal VIN UVLO threshold. The internal VIN UVLO rising threshold is 4.5 V(max) with a typical hysteresis of 150 mV.

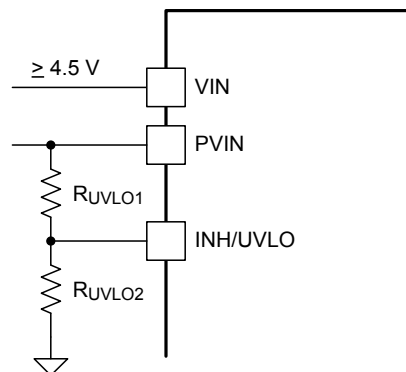
If an application requires either a higher UVLO threshold on the VIN pin or a higher UVLO threshold for a combined VIN and PVIN, then the UVLO pin can be configured as shown in [Figure 42](#) or [Figure 43](#). [Table 10](#) lists standard values for  $R_{UVLO1}$  and  $R_{UVLO2}$  to adjust the VIN UVLO voltage up.



**Table 10. Standard Resistor values for Adjusting VIN UVLO**

| VIN UVLO (V)              | 5.0  | 5.5  | 6.0  | 6.5  | 7.0  | 7.5  | 8.0  | 8.5  | 9.0  | 9.5  | 10.0 |
|---------------------------|------|------|------|------|------|------|------|------|------|------|------|
| $R_{UVLO1}$ (k $\Omega$ ) | 68.1 | 68.1 | 68.1 | 68.1 | 68.1 | 68.1 | 68.1 | 68.1 | 68.1 | 68.1 | 68.1 |
| $R_{UVLO2}$ (k $\Omega$ ) | 21.5 | 18.7 | 16.9 | 15.4 | 14.0 | 13.0 | 12.1 | 11.3 | 10.5 | 9.76 | 9.31 |
| Hysteresis (mV)           | 400  | 415  | 430  | 450  | 465  | 480  | 500  | 515  | 530  | 550  | 565  |

For a split rail application, if a secondary UVLO on PVIN is required, VIN must be  $\geq 4.5$  V. [Figure 44](#) shows the PVIN UVLO configuration. Use [Table 11](#) to select  $R_{UVLO1}$  and  $R_{UVLO2}$  for PVIN. If PVIN UVLO is set for less than 3.0 V, a 5.1-V zener diode should be added to clamp the voltage on the UVLO pin below 6 V.



**Table 11. Standard Resistor Values for Adjusting PVIN UVLO, (VIN  $\geq 4.5$  V)**

| PVIN UVLO (V)             | 2.9  | 3.0  | 3.5  | 4.0  | 4.5  | For higher PVIN UVLO voltages, see <a href="#">Table 10</a> for resistor values. |
|---------------------------|------|------|------|------|------|--|
| $R_{UVLO1}$ (k $\Omega$ ) | 68.1 | 68.1 | 68.1 | 68.1 | 68.1 |  |
| $R_{UVLO2}$ (k $\Omega$ ) | 47.5 | 44.2 | 34.8 | 28.7 | 24.3 |  |
| Hysteresis (mV)           | 330  | 335  | 350  | 365  | 385  |  |

## 10.22 Layout Considerations

To achieve optimal electrical and thermal performance, an optimized PCB layout is required. Figure 45 through Figure 48, shows a typical PCB layout. Some considerations for an optimized layout are:

- Use large copper areas for power planes (PVIN, VOUT, and PGND) to minimize conduction loss and thermal stress.
- Place ceramic input and output capacitors close to the device pins to minimize high frequency noise.
- Locate additional output capacitors between the ceramic capacitor and the load.
- Keep AGND and PGND separate from one another.
- Place  $R_{SET}$ ,  $R_{RT}$ , and  $C_{SS}$  as close as possible to their respective pins.
- Use multiple vias to connect the power planes to internal layers.

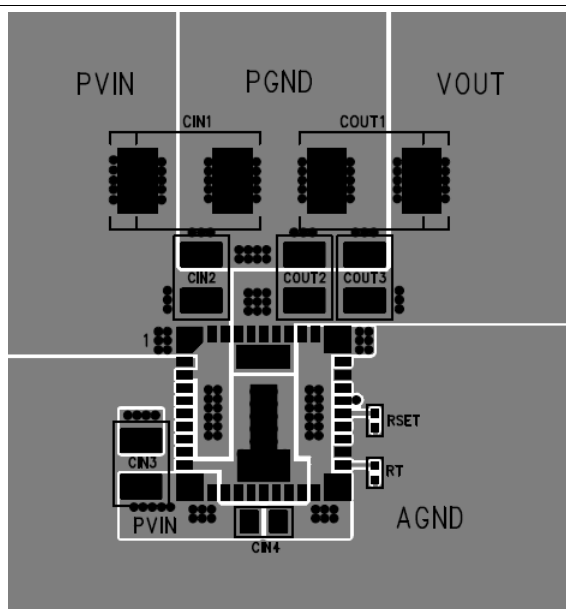


Figure 45. Typical Top-Layer Layout

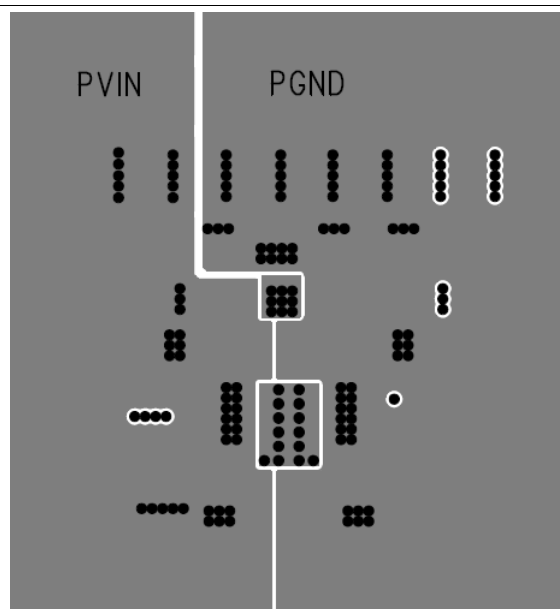


Figure 46. Typical Layer-2 Layout

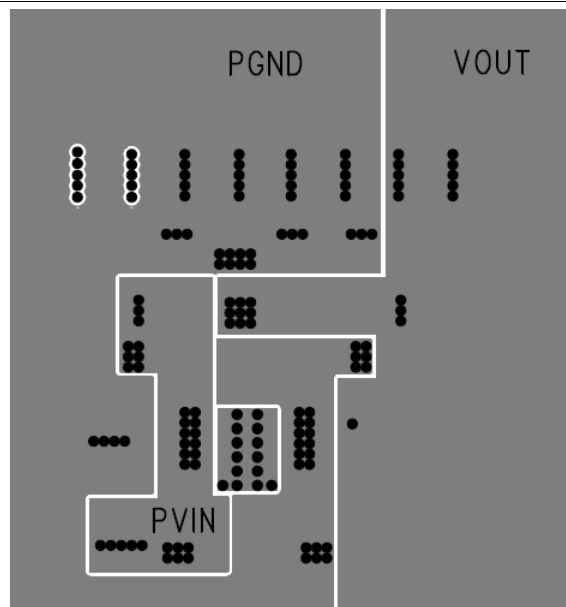


Figure 47. Typical Layer 3 Layout

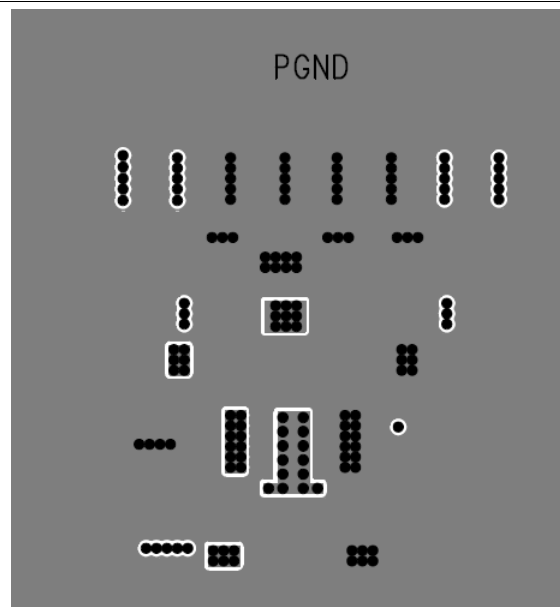
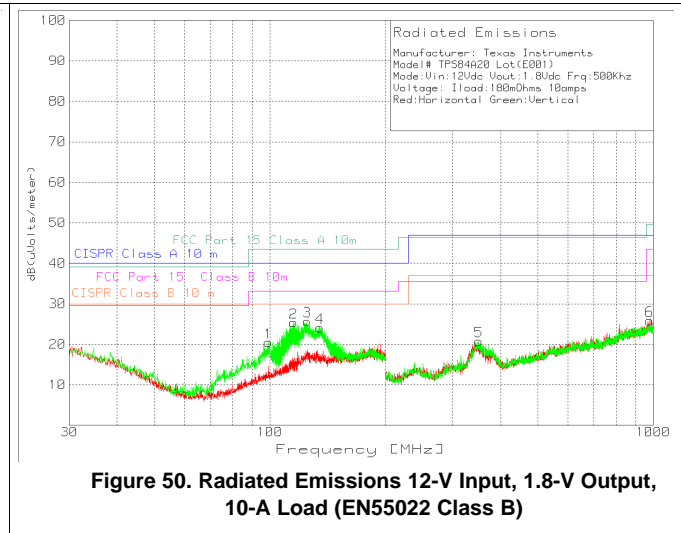
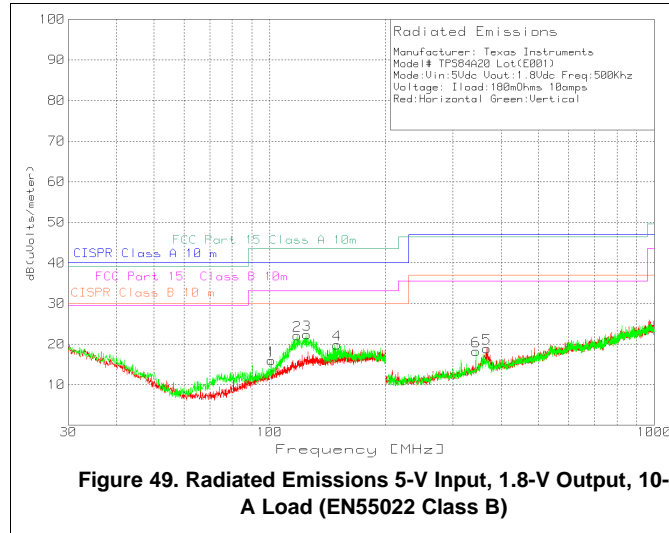


Figure 48. Typical Bottom-Layer Layout

## 10.23 EMI

The TPS84A20 is compliant with EN55022 Class B radiated emissions. [Figure 49](#) and [Figure 50](#) show typical examples of radiated emissions plots for the TPS84A20 operating from 5V and 12V respectively. Both graphs include the plots of the antenna in the horizontal and vertical positions.



## 11 器件和文档支持

### 11.1 接收文档更新通知

要接收文档更新通知，请导航至 [ti.com](http://ti.com) 上的器件产品文件夹。单击右上角的通知我进行注册，即可每周接收产品信息更改摘要。有关更改的详细信息，请查看任何已修订文档中包含的修订历史记录。

### 11.2 支持资源

[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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ESD 的损坏小至导致微小的性能降级，大至整个器件故障。精密的集成电路可能更容易受到损坏，这是因为非常细微的参数更改都可能会导致器件与其发布的规格不相符。

### 11.5 Glossary

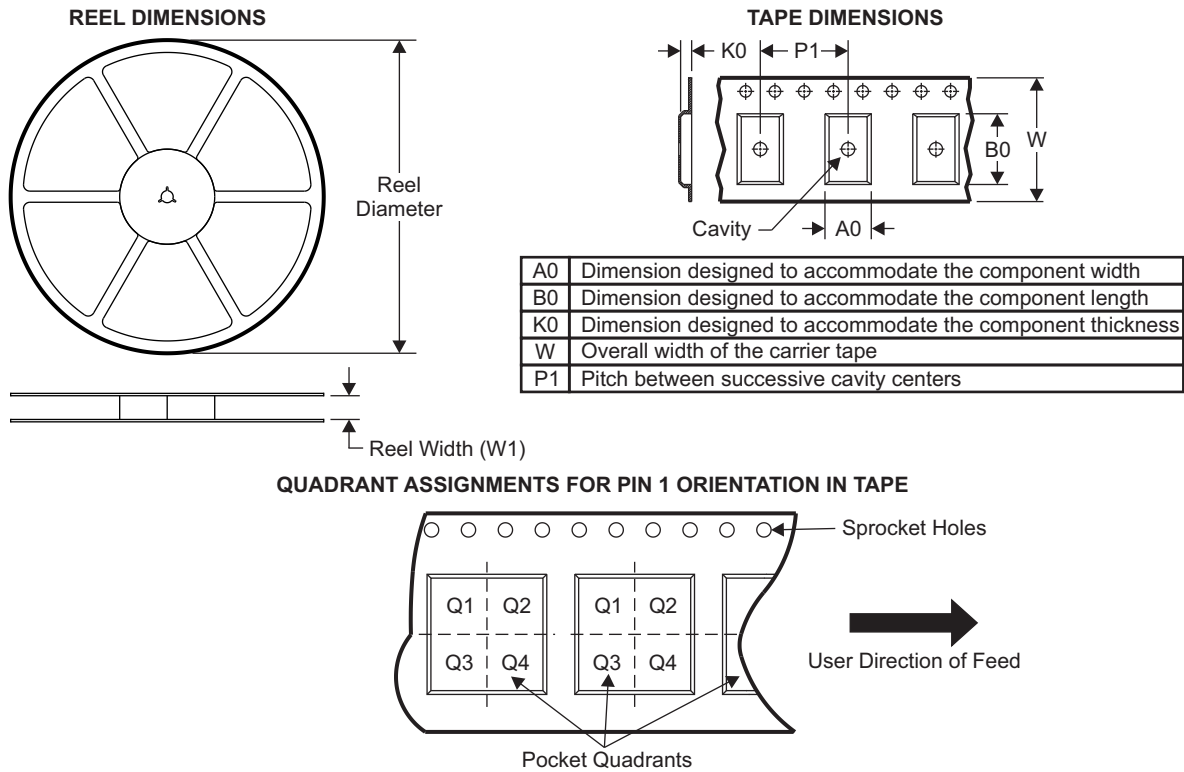
[SLYZ022](#) — *TI Glossary*.

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

## 12 机械、封装和可订购信息

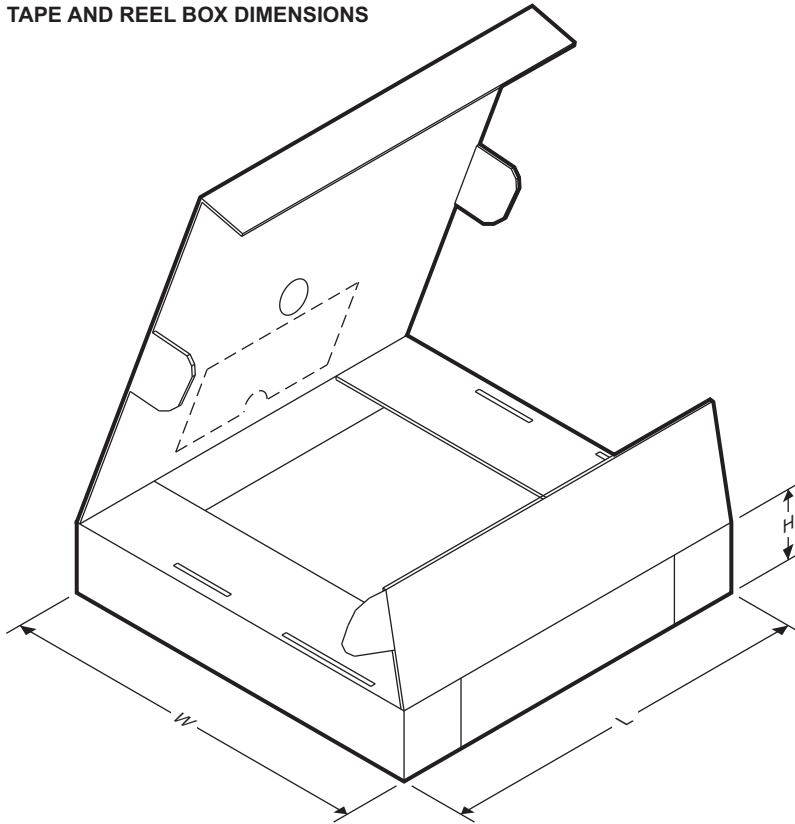
以下页面包含机械、封装和可订购信息。这些信息是指定器件的最新可用数据。数据如有变更，恕不另行通知，且不会对此文档进行修订。如需获取此数据表的浏览器版本，请查阅左侧的导航栏。

### 12.1 Tape and Reel Information



| 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 |
|--------------|--------------|-----------------|------|-----|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| TPS84A20RVQR | B3QFN        | RVQ             | 42   | 500 | 330.0              | 24.4               | 10.35   | 10.35   | 4.6     | 16.0    | 24.0   | Q2            |
| TPS84A20RVQT | B3QFN        | RVQ             | 42   | 250 | 330.0              | 24.4               | 10.35   | 10.35   | 4.6     | 16.0    | 24.0   | Q2            |

**TAPE AND REEL BOX DIMENSIONS**



| Device       | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|--------------|--------------|-----------------|------|-----|-------------|------------|-------------|
| TPS84A20RVQR | B3QFN        | RVQ             | 42   | 500 | 383.0       | 353.0      | 58.0        |
| TPS84A20RVQT | B3QFN        | RVQ             | 42   | 250 | 383.0       | 353.0      | 58.0        |

## PACKAGING INFORMATION

| Orderable part number        | Status<br>(1) | Material type<br>(2) | Package   Pins   | Package qty   Carrier | RoHS<br>(3) | Lead finish/<br>Ball material<br>(4) | MSL rating/<br>Peak reflow<br>(5) | Op temp (°C) | Part marking<br>(6) |
|------------------------------|---------------|----------------------|------------------|-----------------------|-------------|--------------------------------------|-----------------------------------|--------------|---------------------|
| <a href="#">TPS84A20RVQR</a> | Active        | Production           | B3QFN (RVQ)   42 | 500   LARGE T&R       | Exempt      | NIPDAU                               | Level-3-245C-168 HR               | -40 to 85    | (54020, TPS84A20)   |
| TPS84A20RVQR.A               | Active        | Production           | B3QFN (RVQ)   42 | 500   LARGE T&R       | Exempt      | NIPDAU                               | Level-3-245C-168 HR               | -40 to 85    | (54020, TPS84A20)   |
| TPS84A20RVQRG4               | Active        | Production           | B3QFN (RVQ)   42 | 500   LARGE T&R       | Yes         | NIPDAU                               | Level-3-245C-168 HR               | -40 to 85    | TPS84A20            |
| TPS84A20RVQRG4.A             | Active        | Production           | B3QFN (RVQ)   42 | 500   LARGE T&R       | Yes         | NIPDAU                               | Level-3-245C-168 HR               | -40 to 85    | TPS84A20            |
| TPS84A20RVQRG4.B             | Active        | Production           | B3QFN (RVQ)   42 | 500   LARGE T&R       | Yes         | NIPDAU                               | Level-3-245C-168 HR               | -40 to 85    | TPS84A20            |
| <a href="#">TPS84A20RVQT</a> | Active        | Production           | B3QFN (RVQ)   42 | 250   SMALL T&R       | Exempt      | NIPDAU                               | Level-3-245C-168 HR               | -40 to 85    | (54020, TPS84A20)   |
| TPS84A20RVQT.A               | Active        | Production           | B3QFN (RVQ)   42 | 250   SMALL T&R       | Exempt      | NIPDAU                               | Level-3-245C-168 HR               | -40 to 85    | (54020, TPS84A20)   |

<sup>(1)</sup> **Status:** For more details on status, see our [product life cycle](#).

<sup>(2)</sup> **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.

<sup>(3)</sup> **RoHS values:** Yes, No, RoHS Exempt. See the [TI RoHS Statement](#) for additional information and value definition.

<sup>(4)</sup> **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.

<sup>(5)</sup> **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.

<sup>(6)</sup> **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 |
|----------------|--------------|-----------------|------|-----|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| TPS84A20RVQR   | B3QFN        | RVQ             | 42   | 500 | 330.0              | 24.4               | 10.35   | 10.35   | 4.6     | 16.0    | 24.0   | Q2            |
| TPS84A20RVQRG4 | B3QFN        | RVQ             | 42   | 500 | 330.0              | 24.4               | 10.35   | 10.35   | 4.6     | 16.0    | 24.0   | Q2            |
| TPS84A20RVQT   | B3QFN        | RVQ             | 42   | 250 | 330.0              | 24.4               | 10.35   | 10.35   | 4.6     | 16.0    | 24.0   | Q2            |

## TAPE AND REEL BOX DIMENSIONS



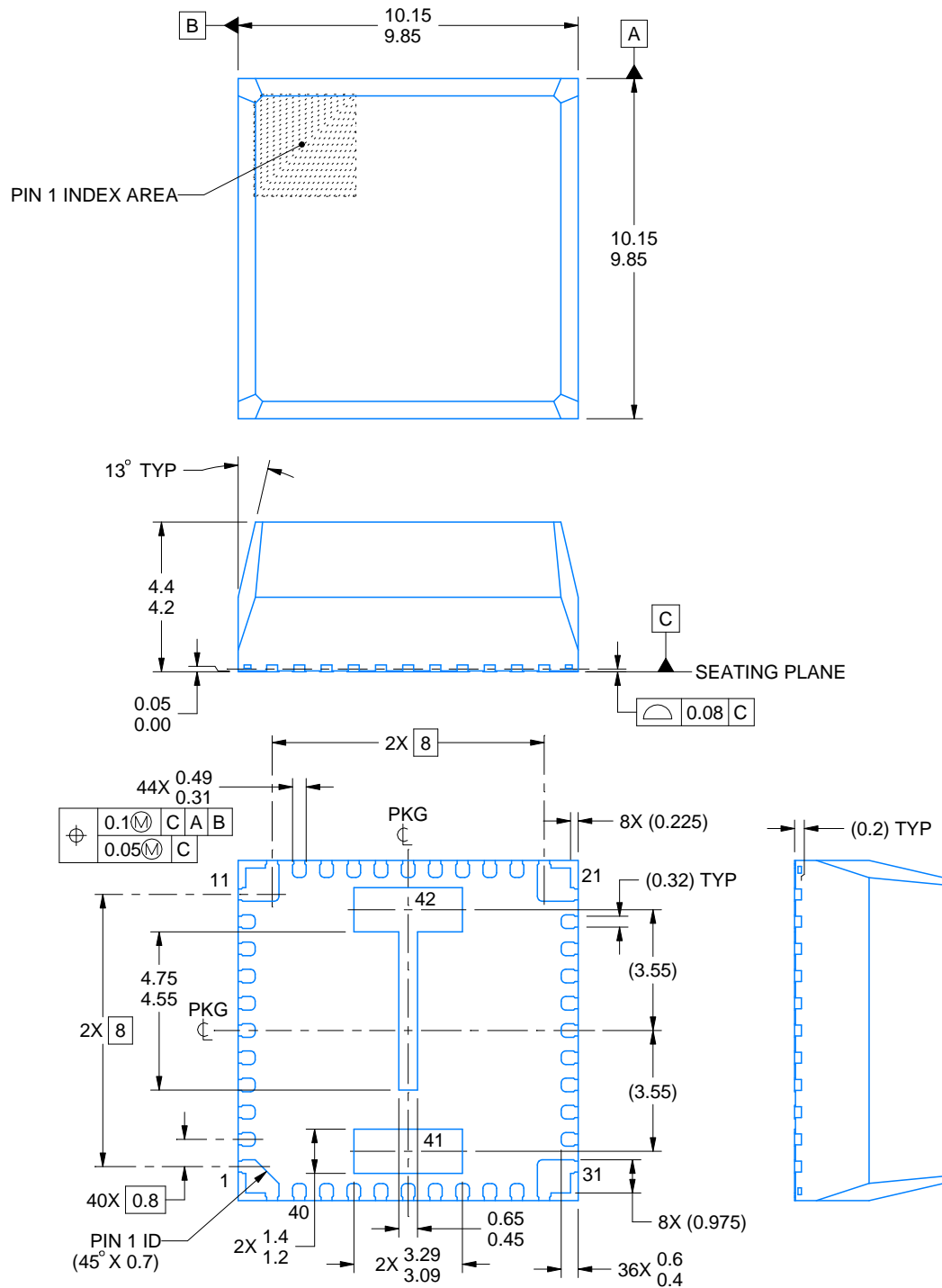
\*All dimensions are nominal

| Device         | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|----------------|--------------|-----------------|------|-----|-------------|------------|-------------|
| TPS84A20RVQR   | B3QFN        | RVQ             | 42   | 500 | 383.0       | 353.0      | 58.0        |
| TPS84A20RVQRG4 | B3QFN        | RVQ             | 42   | 500 | 383.0       | 353.0      | 58.0        |
| TPS84A20RVQT   | B3QFN        | RVQ             | 42   | 250 | 383.0       | 353.0      | 58.0        |

RVQ0042A

### B3QFN - 4.4 mm max height

SUPER THICK QUAD FLATPACK - NO LEAD



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NOTES:

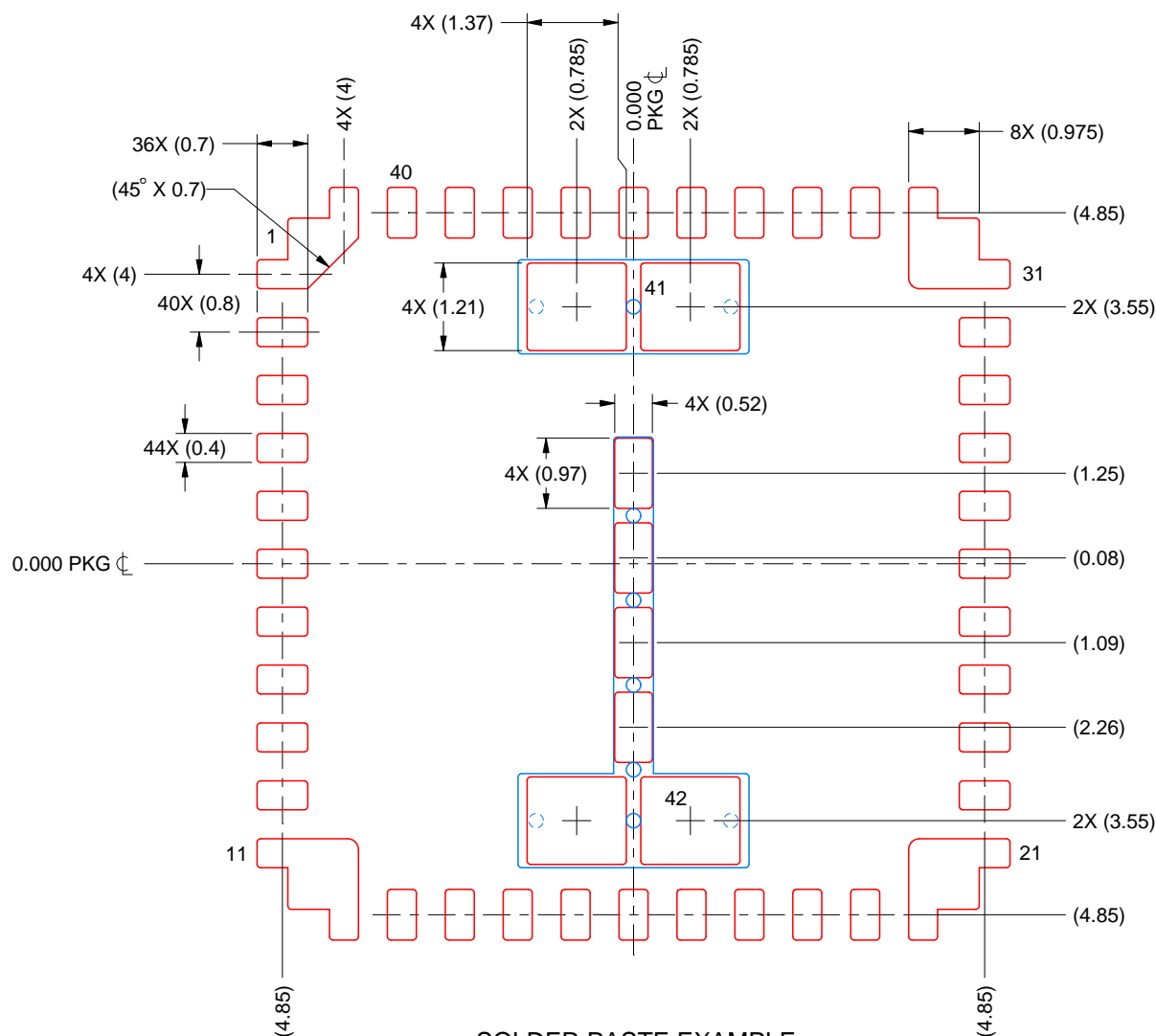
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. The package thermal pad must be soldered to the printed circuit board for thermal and mechanical performance.



RVQ0042A

### B3QFN - 4.4 mm max height

SUPER THICK QUAD FLATPACK - NO LEAD



**SOLDER PASTE EXAMPLE**  
**BASED ON 0.1 mm STENCIL THICKNESS**  
**SCALE: 10X**

### PRINTED SOLDER COVERAGE BY AREA UNDER PACKAGE

PAD 41: 81%

PAD 42: 80%

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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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