



# TPS56x210A、4.5V～17V入力、2A、3A同期整流降压型レギュレータ 8ピンSOT-23パッケージ

## 1 特長

- TPS562210A: 133mΩおよび80mΩ FET内蔵2Aコンバータ
- TPS563210A: 68mΩおよび39mΩ FET内蔵3Aコンバータ
- D-CAP2™モード制御による高速過渡応答
- 高度な Eco-mode™パルス・スキップ
- 入力電圧範囲: 4.5V～17V
- 出力電圧範囲: 0.76V～7V
- 650kHzのスイッチング周波数
- 低いシャットダウン電流: 10μA未満
- 帰還電圧精度: 1% (25℃)
- プリバイアス出力電圧からのスタートアップ
- サイクルごとの過電流制限
- ヒカップ・モード低電圧保護
- 非ラッチ型のOVP、UVLO、およびTSD保護
- 調整可能なソフト・スタート
- パワー・グッド出力

## 2 アプリケーション

- デジタル・テレビ用電源
- 高精細 Blu-ray Disc™ プレーヤー
- ネットワーク・ホーム・ターミナル
- デジタル・セットトップ・ボックス (STB)

## 3 概要

TPS562210AおよびTPS563210Aは、シンプルで使いやすい2A、3A同期整流降压型コンバータで、8ピンSOT-23パッケージで供給されます。

最小の外部部品数で動作し、スタンバイ電流が小さくなるよう最適化されています。

これらのスイッチ・モード電源 (SMPS) デバイスは、D-CAP2™モード制御を採用し、高速の過渡応答を実現します。また、特殊ポリマーなどの低ESR (等価直列抵抗) 出力コンデンサと超低ESRセラミック・コンデンサの両方を外部補償部品なしでサポートします。

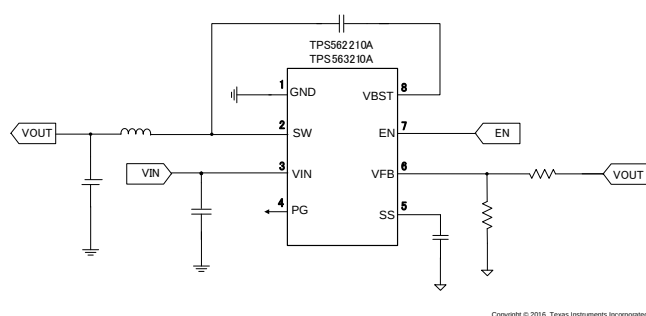
高度なEco-mode™を搭載し、軽負荷動作中も高い効率を維持します。TPS562210AおよびTPS563210Aは、8ピン1.6 × 2.9 (mm) SOT (DDF)パッケージで供給され、-40℃～85℃の周囲温度範囲で仕様が規定されています。

### 製品情報<sup>(1)</sup>

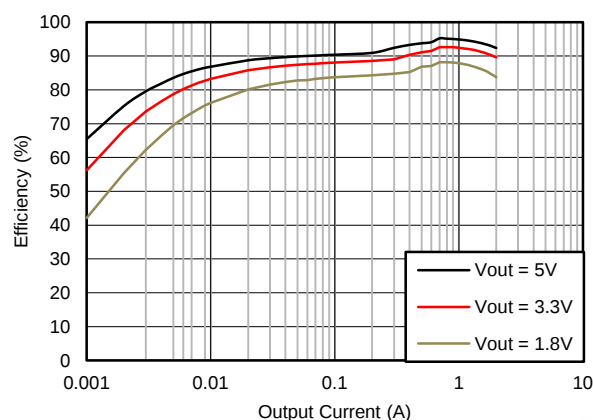
| 発注型番       | パッケージ  | 本体サイズ(公称)     |
|------------|--------|---------------|
| TPS562210A | DDF(8) | 1.60mm×2.90mm |
| TPS563210A |        |               |

(1) 利用可能なすべてのパッケージについては、このデータシートの末尾にある注文情報を参照してください。

概略回路図



効率



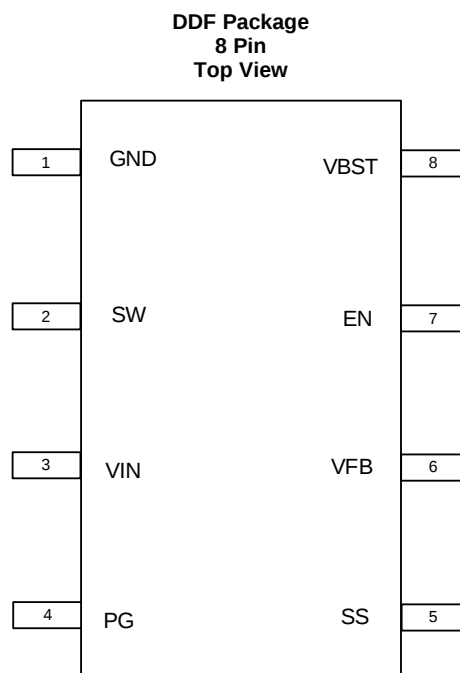
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## 4 改訂履歴

| 日付       | 改訂内容 | 注  |
|----------|------|----|
| 2016年11月 | *    | 初版 |

## 5 Pin Configuration and Functions



### Pin Functions

| PIN  |     | DESCRIPTION                                                                                                                                                   |
|------|-----|---------------------------------------------------------------------------------------------------------------------------------------------------------------|
| NAME | NO. |                                                                                                                                                               |
| GND  | 1   | Ground pin Source terminal of low-side power NFET as well as the ground terminal for controller circuit. Connect sensitive VFB to this GND at a single point. |
| SW   | 2   | Switch node connection between high-side NFET and low-side NFET.                                                                                              |
| VIN  | 3   | Input voltage supply pin. The drain terminal of high-side power NFET.                                                                                         |
| PG   | 4   | Power good open drain output                                                                                                                                  |
| SS   | 5   | Soft-start control. An external capacitor should be connected to GND.                                                                                         |
| VFB  | 6   | Converter feedback input. Connect to output voltage with feedback resistor divider.                                                                           |
| EN   | 7   | Enable input control. Active high and must be pulled up to enable the device.                                                                                 |
| VBST | 8   | Supply input for the high-side NFET gate drive circuit. Connect 0.1 $\mu$ F capacitor between VBST and SW pins.                                               |

## 6 Specifications

### 6.1 Absolute Maximum Ratings

 $T_J = -40^{\circ}\text{C}$  to  $150^{\circ}\text{C}$  (unless otherwise noted) <sup>(1)</sup>

|                                       |                        | MIN  | MAX  | UNIT               |
|---------------------------------------|------------------------|------|------|--------------------|
| Input voltage range                   | VIN, EN                | –0.3 | 19   | V                  |
|                                       | VBST                   | –0.3 | 25   | V                  |
|                                       | VBST (10 ns transient) | –0.3 | 27.5 | V                  |
|                                       | VBST (vs SW)           | –0.3 | 6.5  | V                  |
|                                       | VFB, PG                | –0.3 | 6.5  | V                  |
|                                       | SS                     | –0.3 | 5.5  | V                  |
|                                       | SW                     | –2   | 19   | V                  |
|                                       | SW (10 ns transient)   | –3.5 | 21   | V                  |
| Operating junction temperature, $T_J$ |                        | –40  | 150  | $^{\circ}\text{C}$ |
| Storage temperature, $T_{\text{stg}}$ |                        | –55  | 150  | $^{\circ}\text{C}$ |

- (1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

### 6.2 ESD Ratings

|                  |                         |                                                                                | VALUE | UNIT |
|------------------|-------------------------|--------------------------------------------------------------------------------|-------|------|
| $V_{\text{ESD}}$ | Electrostatic discharge | Human body model (HBM), per ANSI/ESDA/JEDEC JS-001 <sup>(1)</sup>              | ±2000 | V    |
|                  |                         | Charged device model (CDM), per JEDEC specification JESD22-C101 <sup>(2)</sup> | ±500  | V    |

- (1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.  
 (2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

### 6.3 Recommended Operating Conditions

 $T_J = -40^{\circ}\text{C}$  to  $150^{\circ}\text{C}$  (unless otherwise noted)

|                 |                                | MIN                    | MAX  | UNIT |   |
|-----------------|--------------------------------|------------------------|------|------|---|
| V <sub>IN</sub> | Supply input voltage range     | 4.5                    | 17   | V    |   |
| V <sub>I</sub>  | Input voltage range            | VBST                   | −0.1 | 23   | V |
|                 |                                | VBST (10 ns transient) | −0.1 | 26   | V |
|                 |                                | VBST(vs SW)            | −0.1 | 6    | V |
|                 |                                | EN                     | −0.1 | 17   | V |
|                 |                                | VFB, pg                | −0.1 | 5.5  | V |
|                 |                                | SS                     | −0.1 | 5    | V |
|                 |                                | SW                     | −1.8 | 17   | V |
|                 |                                | SW (10 ns transient)   | −3.5 | 20   | V |
| T <sub>A</sub>  | Operating free-air temperature | −40                    | 85   | °C   |   |

### 6.4 Thermal Information

| THERMAL METRIC <sup>(1)</sup> |                                              | TPS562210A   | TPS563210A | UNIT |
|-------------------------------|----------------------------------------------|--------------|------------|------|
|                               |                                              | DDF (8 PINS) |            |      |
| R <sub>θJA</sub>              | Junction-to-ambient thermal resistance       | 106.1        | 87.0       | °C/W |
| R <sub>θJC(top)</sub>         | Junction-to-case (top) thermal resistance    | 49.1         | 41.6       | °C/W |
| R <sub>θJB</sub>              | Junction-to-board thermal resistance         | 10.9         | 14.6       | °C/W |
| Ψ <sub>JT</sub>               | Junction-to-top characterization parameter   | 8.6          | 4.7        | °C/W |
| Ψ <sub>JB</sub>               | Junction-to-board characterization parameter | 10.8         | 14.6       | °C/W |

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

## 6.5 Electrical Characteristics

over operating free-air temperature range, VIN = 12 V (unless otherwise noted)

| PARAMETER                                        |                                                             | TEST CONDITIONS                                                                             | MIN  | TYP                       | MAX  | UNIT   |
|--------------------------------------------------|-------------------------------------------------------------|---------------------------------------------------------------------------------------------|------|---------------------------|------|--------|
| SUPPLY CURRENT                                   |                                                             |                                                                                             |      |                           |      |        |
| I <sub>VIN</sub>                                 | Operating – non-switching supply current                    | V <sub>IN</sub> current, T <sub>A</sub> = 25°C, EN = 5V, V <sub>FB</sub> = 0.8 V            |      | 190                       | 290  | μA     |
| I <sub>VINSDN</sub>                              | Shutdown supply current                                     | V <sub>IN</sub> current, T <sub>A</sub> = 25°C, EN = 0 V                                    |      | 3.0                       | 10   | μA     |
| LOGIC THRESHOLD                                  |                                                             |                                                                                             |      |                           |      |        |
| V <sub>ENH</sub>                                 | EN high-level input voltage                                 | EN                                                                                          | 1.6  |                           |      | V      |
| V <sub>ENL</sub>                                 | EN low-level input voltage                                  | EN                                                                                          |      |                           | 0.6  | V      |
| R <sub>EN</sub>                                  | EN pin resistance to GND                                    | V <sub>EN</sub> = 12 V                                                                      | 225  | 450                       | 900  | kΩ     |
| V <sub>FB</sub> VOLTAGE AND DISCHARGE RESISTANCE |                                                             |                                                                                             |      |                           |      |        |
| V <sub>FBTH</sub>                                | V <sub>FB</sub> threshold voltage TPS562210A                | T <sub>A</sub> = 25°C, V <sub>O</sub> = 1.05 V, I <sub>O</sub> = 10 mA, Eco-mode™ operation |      | 772                       |      | mV     |
|                                                  | V <sub>FB</sub> threshold voltage TPS562210A and TPS563210A | T <sub>A</sub> = 25°C, V <sub>O</sub> = 1.05 V                                              | 758  | 765                       | 772  | mV     |
|                                                  |                                                             | T <sub>A</sub> = 0°C to 85°C, V <sub>O</sub> = 1.05 V <sup>(1)</sup>                        | 753  |                           | 777  |        |
|                                                  |                                                             | T <sub>A</sub> = -40°C to 85°C, V <sub>O</sub> = 1.05 V <sup>(1)</sup>                      | 751  |                           | 779  |        |
| I <sub>VFB</sub>                                 | V <sub>FB</sub> input current                               | V <sub>FB</sub> = 0.8 V, T <sub>A</sub> = 25°C                                              |      | 0                         | ±0.1 | μA     |
| MOSFET                                           |                                                             |                                                                                             |      |                           |      |        |
| R <sub>DS(on)h</sub>                             | High side switch resistance                                 | T <sub>A</sub> = 25°C, V <sub>BST</sub> – SW = 5.5 V, TPS562210A                            |      | 133                       |      | mΩ     |
|                                                  |                                                             | T <sub>A</sub> = 25°C, V <sub>BST</sub> – SW = 5.5 V, TPS563210A                            |      | 68                        |      |        |
| R <sub>DS(on)l</sub>                             | Low side switch resistance                                  | T <sub>A</sub> = 25°C, TPS562210A                                                           |      | 80                        |      | mΩ     |
|                                                  |                                                             | T <sub>A</sub> = 25°C, TPS563210A                                                           |      | 39                        |      |        |
| CURRENT LIMIT                                    |                                                             |                                                                                             |      |                           |      |        |
| I <sub>OCL</sub>                                 | Current limit <sup>(1)</sup>                                | DC current, V <sub>OUT</sub> = 1.05 V , L1 = 2.2 μH, TPS562210A                             | 2.5  | 3.2                       | 4.3  | A      |
|                                                  |                                                             | DC current, V <sub>OUT</sub> = 1.05 V , L1 = 1.5 μH, TPS563210A                             | 3.5  | 4.2                       | 5.3  |        |
| THERMAL SHUTDOWN                                 |                                                             |                                                                                             |      |                           |      |        |
| T <sub>SDN</sub>                                 | Thermal shutdown threshold <sup>(1)</sup>                   | Shutdown temperature                                                                        |      | 155                       |      | °C     |
|                                                  |                                                             | Hysteresis                                                                                  |      | 35                        |      |        |
| SOFT START                                       |                                                             |                                                                                             |      |                           |      |        |
| I <sub>SS</sub>                                  | SS charge current                                           | V <sub>SS</sub> = 1.2 V                                                                     | 4.2  | 6                         | 7.8  | μA     |
| POWER GOOD                                       |                                                             |                                                                                             |      |                           |      |        |
| V <sub>THPG</sub>                                | PG threshold                                                | V <sub>FB</sub> rising (Good)                                                               | 85%  | 90%                       | 95%  |        |
|                                                  |                                                             | V <sub>FB</sub> falling (Fault)                                                             |      | 85%                       |      |        |
| I <sub>PG</sub>                                  | PG sink current                                             | PG = 0.5 V                                                                                  | 0.5  | 1                         |      | mA     |
| OUTPUT UNDERVOLTAGE AND OVERVOLTAGE PROTECTION   |                                                             |                                                                                             |      |                           |      |        |
| V <sub>OVP</sub>                                 | Output OVP threshold                                        | OVP Detect                                                                                  |      | 125%<br>V <sub>fbth</sub> |      |        |
| V <sub>UVP</sub>                                 | Output UVP threshold                                        | Hiccup detect                                                                               |      | 65%<br>V <sub>fbth</sub>  |      |        |
| t <sub>HiccupOn</sub>                            | Hiccup Power On Time                                        | Relative to soft start time                                                                 |      | 1                         |      | cycle  |
| t <sub>HiccupOff</sub>                           | Hiccup Power Off Time                                       | Relative to soft start time                                                                 |      | 7                         |      | cycles |
| UVLO                                             |                                                             |                                                                                             |      |                           |      |        |
| UVLO                                             | UVLO threshold                                              | Wake up VIN voltage                                                                         | 3.45 | 3.75                      | 4.05 | V      |
|                                                  |                                                             | Hysteresis VIN voltage                                                                      | 0.13 | 0.32                      | 0.55 |        |

(1) Not production tested.

## 6.6 Timing Requirements

|                              |                  | MIN                                             | TYP | MAX | UNIT |
|------------------------------|------------------|-------------------------------------------------|-----|-----|------|
| <b>ON-TIME TIMER CONTROL</b> |                  |                                                 |     |     |      |
| t <sub>ON</sub>              | On time          | V <sub>IN</sub> = 12 V, V <sub>O</sub> = 1.05 V | 150 |     | ns   |
| t <sub>OFF(MIN)</sub>        | Minimum off time | T <sub>A</sub> = 25°C, V <sub>FB</sub> = 0.5 V  | 260 | 310 | ns   |

## 6.7 Typical Characteristics

### 6.7.1 TPS562210A Characteristics

$V_{IN} = 12\text{ V}$  (unless otherwise noted)

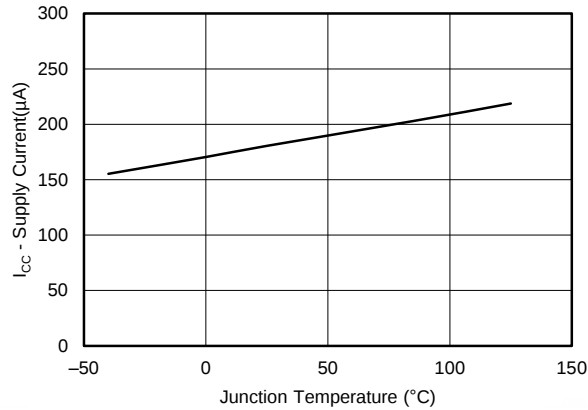


图 1. Supply Current vs Junction Temperature

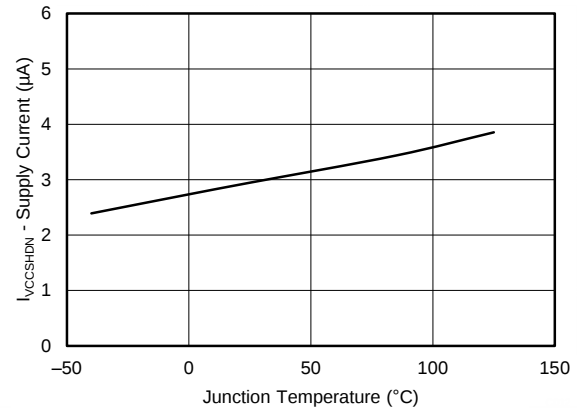


图 2. VIN Shutdown Current vs Junction Temperature

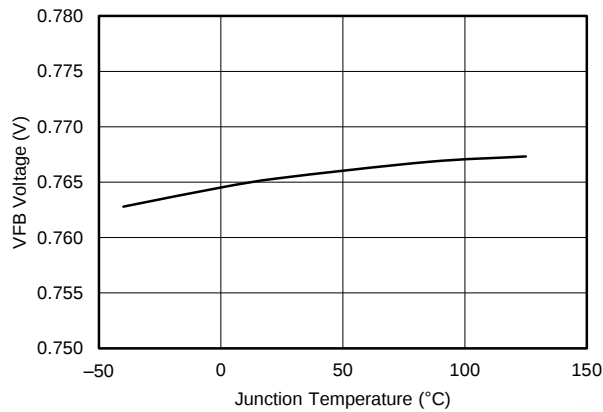


图 3. VFB Voltage vs Junction Temperature

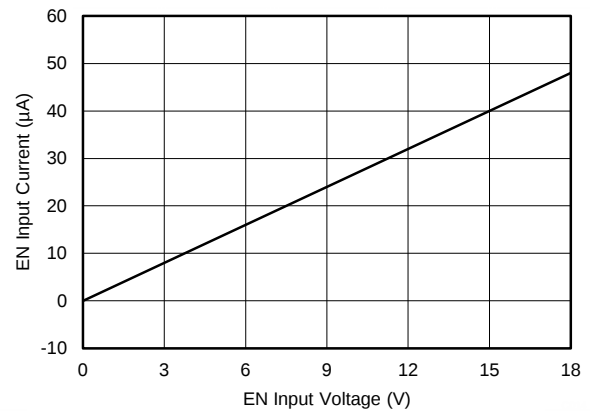


图 4. EN Current vs EN Voltage

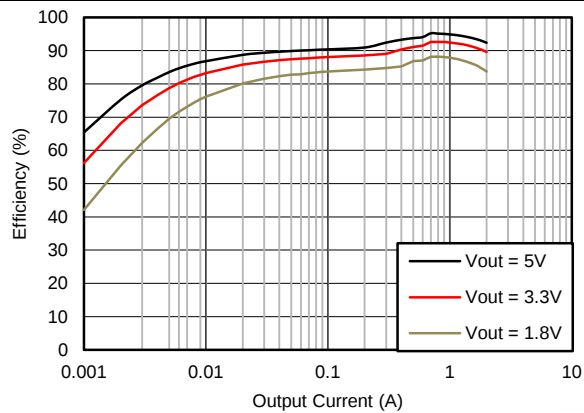


图 5. Efficiency vs Output Current

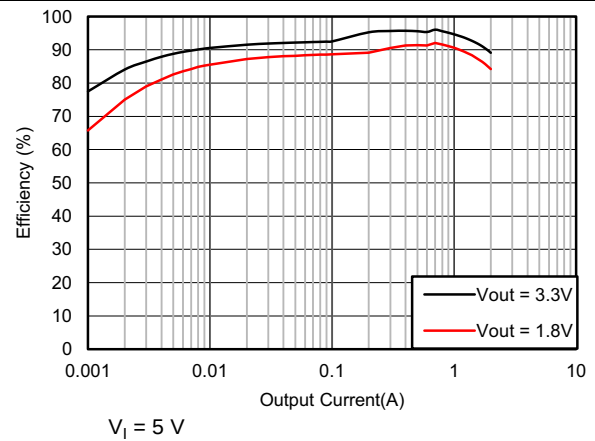


图 6. Efficiency vs Output Current

## TPS562210A Characteristics (continued)

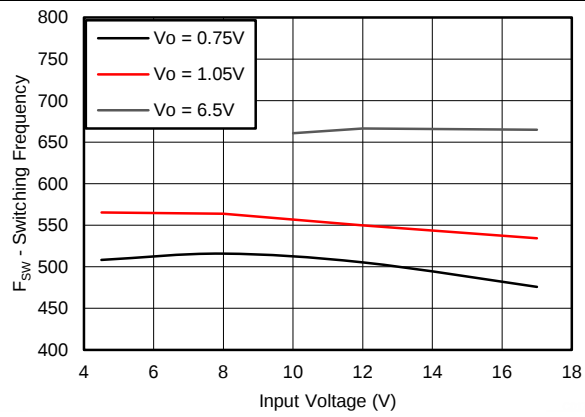


Fig 7. Switching Frequency vs Input Voltage

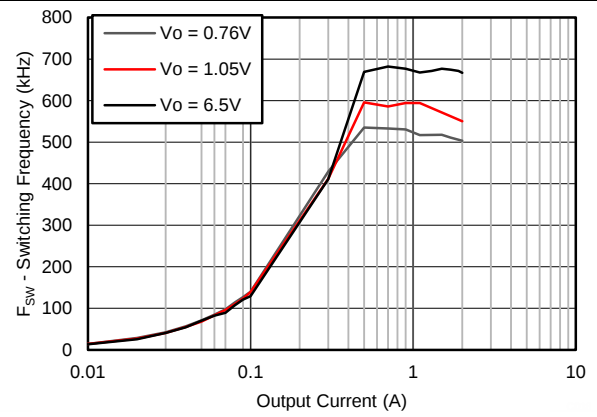


Fig 8. Switching Frequency vs Output Current

## 6.7.2 TPS563210A Characteristics

$V_{IN} = 12V$  (unless otherwise noted)

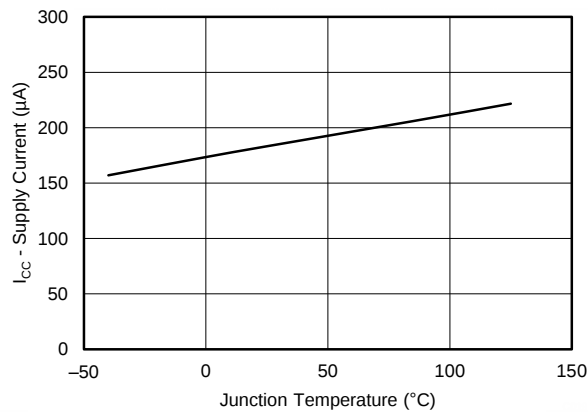


Figure 9. Supply Current vs Junction Temperature

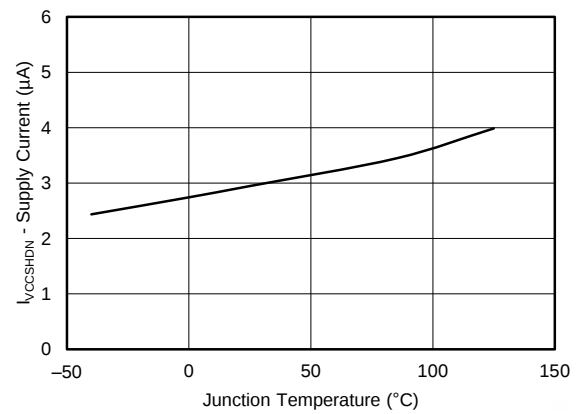


Figure 10. VIN Shutdown Current vs Junction Temperature

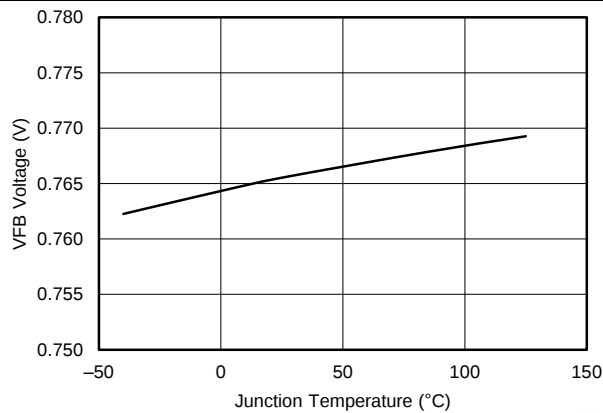


Figure 11. VFB Voltage vs Junction Temperature

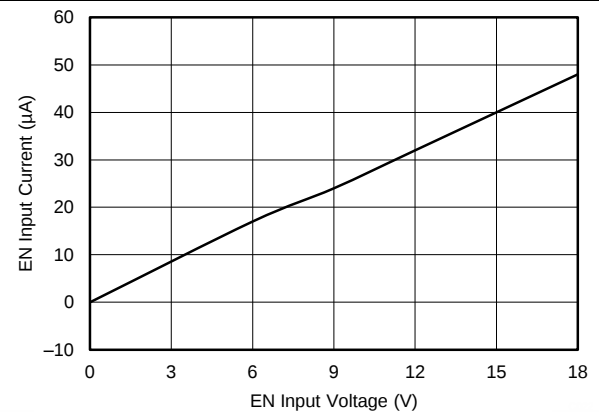


Figure 12. EN Current vs EN Voltage

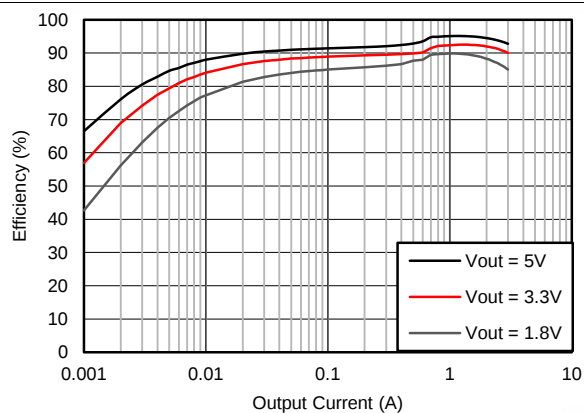


Figure 13. Efficiency vs Output Current

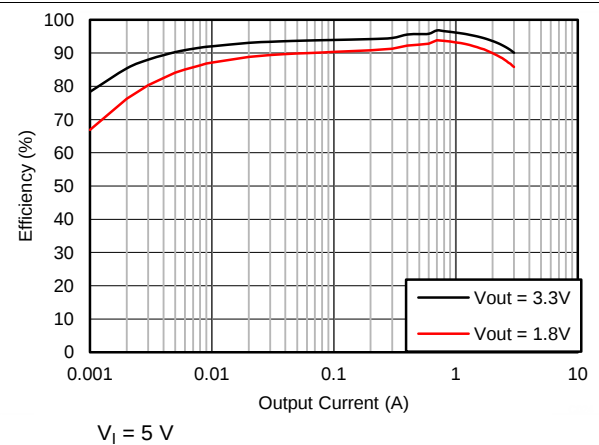
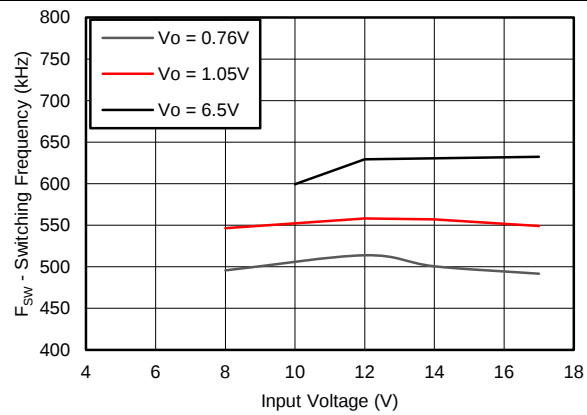
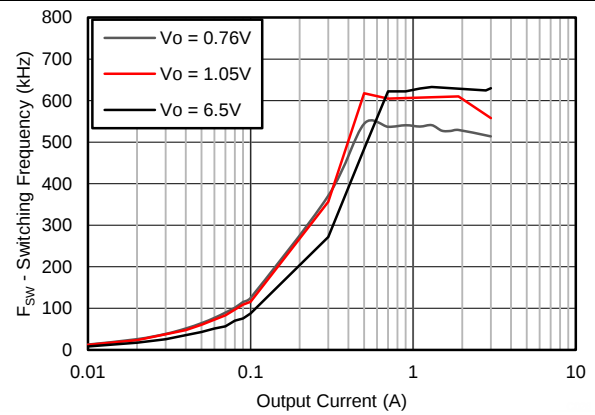


Figure 14. Efficiency vs Output Current

## TPS563210A Characteristics (continued)



ⓧ 15. Switching Frequency vs Input Voltage



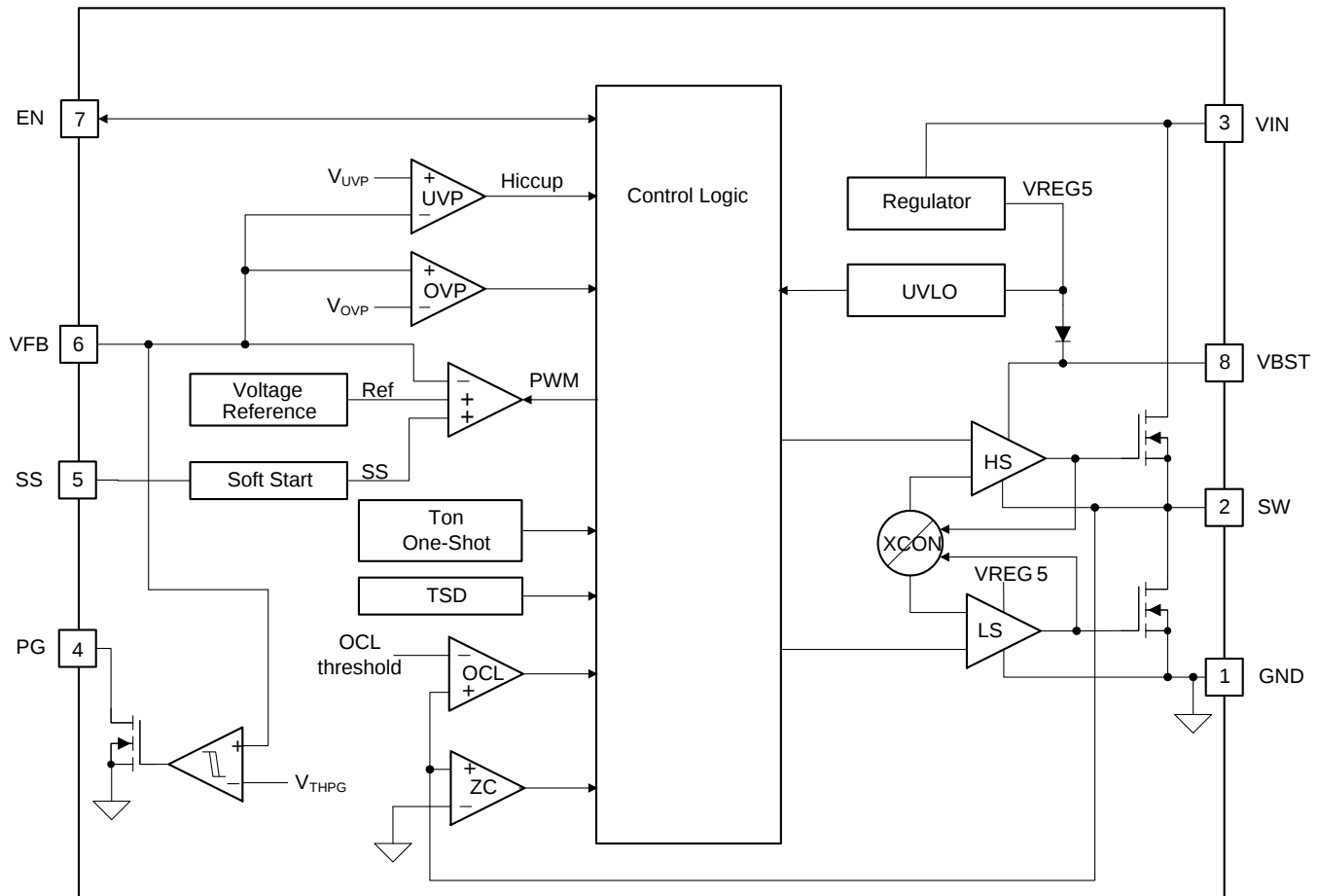
ⓧ 16. Switching Frequency vs Output Current

## 7 Detailed Description

### 7.1 Overview

The TPS562210A and TPS563210A are 2-A, 3-A synchronous step-down converters. The proprietary D-CAP2™ mode control supports low ESR output capacitors such as specialty polymer capacitors and multi-layer ceramic capacitors without complex external compensation circuits. The fast transient response of D-CAP2™ mode control can reduce the output capacitance required to meet a specific level of performance.

### 7.2 Functional Block Diagram



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## 7.3 Feature Description

### 7.3.1 The Adaptive On-Time Control and PWM Operation

The main control loop of the TPS562210A and TPS563210A are adaptive on-time pulse width modulation (PWM) controller that supports a proprietary D-CAP2™ mode control. The D-CAP2™ mode control combines adaptive on-time control with an internal compensation circuit for pseudo-fixed frequency and low external component count configuration with both low ESR and ceramic output capacitors. It is stable even with virtually no ripple at the output.

At the beginning of each cycle, the high-side MOSFET is turned on. This MOSFET is turned off after internal one shot timer expires. This one shot duration is set proportional to the converter input voltage, VIN, and inversely proportional to the output voltage, VO, to maintain a pseudo-fixed frequency over the input voltage range, hence it is called adaptive on-time control. The one-shot timer is reset and the high-side MOSFET is turned on again when the feedback voltage falls below the reference voltage. An internal ramp is added to reference voltage to simulate output ripple, eliminating the need for ESR induced output ripple from D-CAP2™ mode control.

### 7.3.2 Soft Start and Pre-Biased Soft Start

The TPS562210A and TPS563210A have adjustable soft-start. When the EN pin becomes high, the SS charge current (ISS) begins charging the capacitor which is connected from the SS pin to GND (CSS). Smooth control of the output voltage is maintained during start up. The equation for the soft start time, Tss is shown in 式 1.

$$T_{ss}(ms) = \frac{C_{ss} \times V_{FBTH} \times 0.86}{I_{ss}} \quad (1)$$

where VFBTH is 0.765 V and Iss is 6 μA.

If the output capacitor is pre-biased at startup, the devices initiate switching and start ramping up only after the internal reference voltage becomes greater than the feedback voltage VFB. This scheme ensures that the converters ramp up smoothly into regulation point.

### 7.3.3 Power Good

The power good output, PG is an open drain output. The power good function becomes active after 1.7 times soft-start time. When the output voltage becomes within –10% of the target value, internal comparators detect power good state and the power good signal becomes high. If the feedback voltage goes under 15% of the target value, the power good signal becomes low.

### 7.3.4 Current Protection

The output over-current limit (OCL) is implemented using a cycle-by-cycle valley detect control circuit. The switch current is monitored during the OFF state by measuring the low-side FET drain to source voltage. This voltage is proportional to the switch current. To improve accuracy, the voltage sensing is temperature compensated.

During the on time of the high-side FET switch, the switch current increases at a linear rate determined by VIN, VOUT, the on-time and the output inductor value. During the on time of the low-side FET switch, this current decreases linearly. The average value of the switch current is the load current IOUT. If the monitored current is above the OCL level, the converter maintains low-side FET on and delays the creation of a new set pulse, even the voltage feedback loop requires one, until the current level becomes OCL level or lower. In subsequent switching cycles, the on-time is set to a fixed value and the current is monitored in the same manner. If the over current condition exists consecutive switching cycles, the internal OCL threshold is set to a lower level, reducing the available output current. When a switching cycle occurs where the switch current is not above the lower OCL threshold, the counter is reset and the OCL threshold is returned to the higher value.

There are some important considerations for this type of over-current protection. The load current is higher than the over-current threshold by one half of the peak-to-peak inductor ripple current. Also, when the current is being limited, the output voltage tends to fall as the demanded load current may be higher than the current available from the converter. This may cause the output voltage to fall. When the VFB voltage falls below the UVP threshold voltage, the UVP comparator detects it. And then, the device will shut down after the UVP delay time (typically 14 μs) and re-start after the hiccup time.

When the over current condition is removed, the output voltage returns to the regulated value.

## Feature Description (continued)

### 7.3.5 Over Voltage Protection

TPS562210A and TPS563210A detect over voltage condition by monitoring the feedback voltage (VFB). When the feedback voltage becomes higher than 125% of the target voltage, the OVP comparator output goes high and the high-side MOSFET is turns off. This function is non-latch operation.

### 7.3.6 UVLO Protection

Under voltage lock out protection (UVLO) monitors the internal regulator voltage. When the voltage is lower than UVLO threshold voltage, the device is shut off. This protection is non-latching.

### 7.3.7 Thermal Shutdown

The device monitors the temperature of itself. If the temperature exceeds the threshold value (typically 155°C), the device is shut off. This is a non-latch protection.

## 7.4 Device Functional Modes

### 7.4.1 Advanced Eco-Mode™ Control

The TPS562210A and TPS563210A are designed with Advanced Eco-mode™ to maintain high light load efficiency. As the output current decreases from heavy load condition, the inductor current is also reduced and eventually comes to point that its rippled valley touches zero level, which is the boundary between continuous conduction and discontinuous conduction modes. The rectifying MOSFET is turned off when the zero inductor current is detected. As the load current further decreases the converter runs into discontinuous conduction mode. The on-time is kept almost the same as it was in the continuous conduction mode so that it takes longer time to discharge the output capacitor with smaller load current to the level of the reference voltage. This makes the switching frequency lower, proportional to the load current, and keeps the light load efficiency high. The transition point to the light load operation  $I_{OUT(LL)}$  current can be calculated in 式 2.

$$I_{OUT(LL)} = \frac{1}{2 \times L \times f_{SW}} \times \frac{(V_{IN} - V_{OUT}) \times V_{OUT}}{V_{IN}} \quad (2)$$

## 8 Application and Implementation

### 注

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

### 8.1 Application Information

The TPS562210A and TPS563210A are typically used as step down converters, which convert a voltage from 4.5 V to 17 V to a lower voltage. Webench software is available to aid in the design and analysis of circuits.

### 8.2 Typical Application

#### 8.2.1 Typical Application, TPS562210A

4.5-V to 17-V Input, 1.05-V Output Converter.

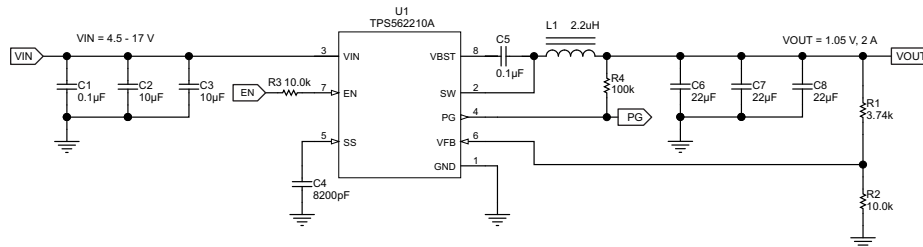


图 17. TPS562210A 1.05V/2A Reference Design

##### 8.2.1.1 Design Requirements

For this design example, use the parameters shown in 表 1.

表 1. Design Parameters

| PARAMETER             | VALUES        |
|-----------------------|---------------|
| Input voltage range   | 4.5 V to 17 V |
| Output voltage        | 1.05 V        |
| Output current        | 2 A           |
| Output voltage ripple | 20 mVp-p      |

##### 8.2.1.2 Detailed Design Procedure

###### 8.2.1.2.1 Output Voltage Resistors Selection

The output voltage is set with a resistor divider from the output node to the VFB pin. It is recommended to use 1% tolerance or better divider resistors. Start by using 式 3 to calculate  $V_{OUT}$ .

To improve efficiency at light loads consider using larger value resistors, too high of resistance are more susceptible to noise and voltage errors from the VFB input current are more noticeable.

$$V_{OUT} = 0.765 \times \left( 1 + \frac{R1}{R2} \right) \quad (3)$$

###### 8.2.1.2.2 Output Filter Selection

The LC filter used as the output filter has double pole at:

$$F_P = \frac{1}{2\pi\sqrt{L_{OUT} \times C_{OUT}}} \quad (4)$$

At low frequencies, the overall loop gain is set by the output set-point resistor divider network and the internal gain of the device. The low frequency phase is 180 degrees. At the output filter pole frequency, the gain rolls off at a –40 dB per decade rate and the phase drops rapidly. D-CAP2™ introduces a high frequency zero that reduces the gain roll off to –20 dB per decade and increases the phase to 90 degrees one decade above the zero frequency. The inductor and capacitor for the output filter must be selected so that the double pole of 式 4 is located below the high frequency zero but close enough that the phase boost provided by the high frequency zero provides adequate phase margin for a stable circuit. To meet this requirement use the values recommended in 表 2.

**表 2. TPS562210A Recommended Component Values**

| Output Voltage (V) | R2 (kΩ) | R3 (kΩ) | L1 (μH) |     |     | C6 + C7 + C8 (μF) |
|--------------------|---------|---------|---------|-----|-----|-------------------|
|                    |         |         | MIN     | TYP | MAX |                   |
| 1                  | 3.09    | 10.0    | 1.5     | 2.2 | 4.7 | 20 - 68           |
| 1.05               | 3.74    | 10.0    | 1.5     | 2.2 | 4.7 | 20 - 68           |
| 1.2                | 5.76    | 10.0    | 1.5     | 2.2 | 4.7 | 20 - 68           |
| 1.5                | 9.53    | 10.0    | 1.5     | 2.2 | 4.7 | 20 - 68           |
| 1.8                | 13.7    | 10.0    | 1.5     | 2.2 | 4.7 | 20 - 68           |
| 2.5                | 22.6    | 10.0    | 2.2     | 3.3 | 4.7 | 20 - 68           |
| 3.3                | 33.2    | 10.0    | 2.2     | 3.3 | 4.7 | 20 - 68           |
| 5                  | 54.9    | 10.0    | 3.3     | 4.7 | 4.7 | 20 - 68           |
| 6.5                | 75      | 10.0    | 3.3     | 4.7 | 4.7 | 20 - 68           |

The inductor peak-to-peak ripple current, peak current and RMS current are calculated using 式 5, 式 6 and 式 7. The inductor saturation current rating must be greater than the calculated peak current and the RMS or heating current rating must be greater than the calculated RMS current.

Use 650 kHz for  $f_{SW}$ . Make sure the chosen inductor is rated for the peak current of 式 6 and the RMS current of 式 7.

$$I_{P-P} = \frac{V_{OUT}}{V_{IN(MAX)}} \times \frac{V_{IN(MAX)} - V_{OUT}}{L_O \times f_{SW}} \quad (5)$$

$$I_{PEAK} = I_O + \frac{I_{P-P}}{2} \quad (6)$$

$$I_{LO(RMS)} = \sqrt{I_O^2 + \frac{1}{12} I_{P-P}^2} \quad (7)$$

For this design example, the calculated peak current is 2.34 A and the calculated RMS current is 2.01 A. The inductor used is a TDK CLF7045T-2R2N with a peak current rating of 5.5 A and an RMS current rating of 4.3 A.

The capacitor value and ESR determines the amount of output voltage ripple. The TPS562210A and TPS563210A are intended for use with ceramic or other low ESR capacitors. Recommended values range from 20μF to 68μF. Use 式 8 to determine the required RMS current rating for the output capacitor.

$$I_{CO(RMS)} = \frac{V_{OUT} \times (V_{IN} - V_{OUT})}{\sqrt{12} \times V_{IN} \times L_O \times f_{SW}} \quad (8)$$

For this design, two TDK C3216X5R0J226M 22 μF output capacitors are used. The typical ESR is 2 mΩ each. The calculated RMS current is 0.286A and each output capacitor is rated for 4A.

### 8.2.1.2.3 Input Capacitor Selection

The TPS562210A and TPS563210A require an input decoupling capacitor and a bulk capacitor is needed depending on the application. A ceramic capacitor over 10 μF is recommended for the decoupling capacitor. An additional 0.1 μF capacitor (C3) from pin 3 to ground is optional to provide additional high frequency filtering. The capacitor voltage rating needs to be greater than the maximum input voltage.

#### 8.2.1.2.4 Bootstrap capacitor Selection

A 0.1 $\mu$ F ceramic capacitor must be connected between the VBST to SW pin for proper operation. It is recommended to use a ceramic capacitor.

#### 8.2.1.3 Application Curves

The following application curves were generated using the application circuit of [Figure 17](#).

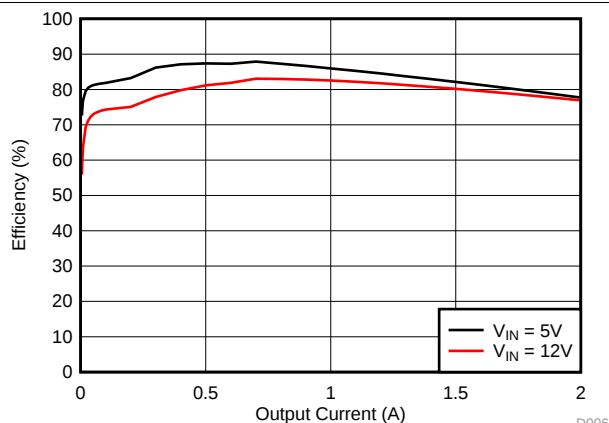


Figure 18. TPS562210A Efficiency

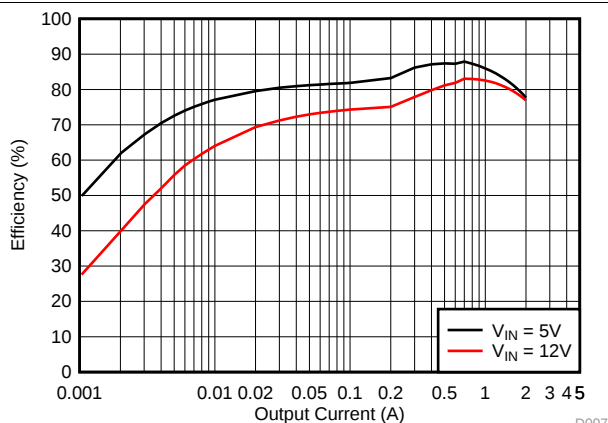


Figure 19. TPS562210A Light Load Efficiency

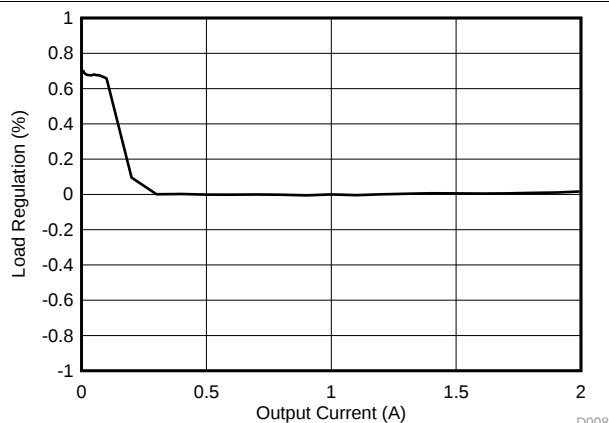


Figure 20. TPS562210A Load Regulation,  $V_I = 5\text{ V}$

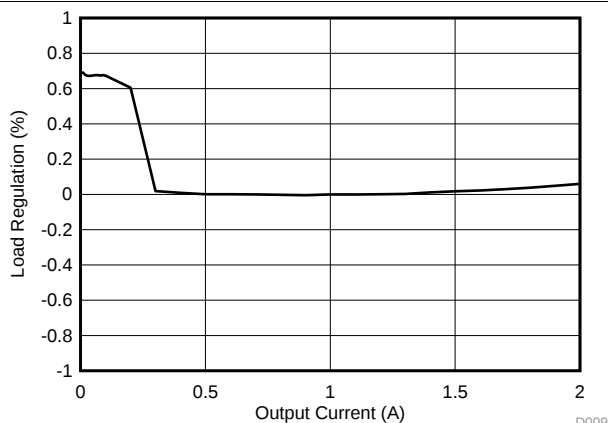


Figure 21. TPS562210A Load Regulation,  $V_I = 12\text{ V}$

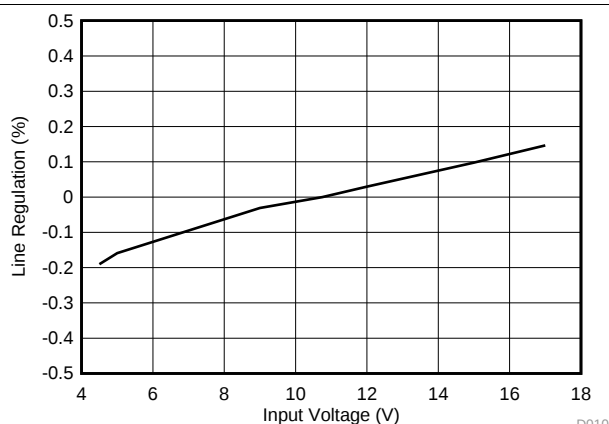


Figure 22. TPS562210A Line Regulation

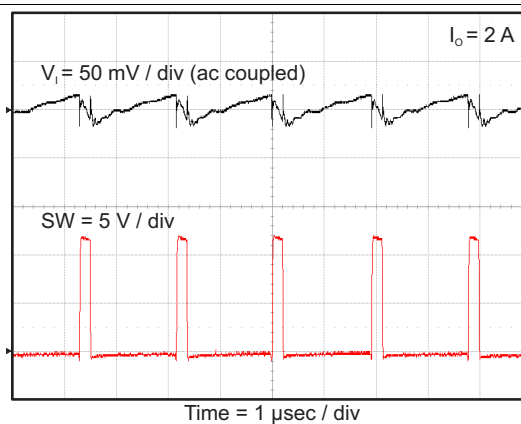
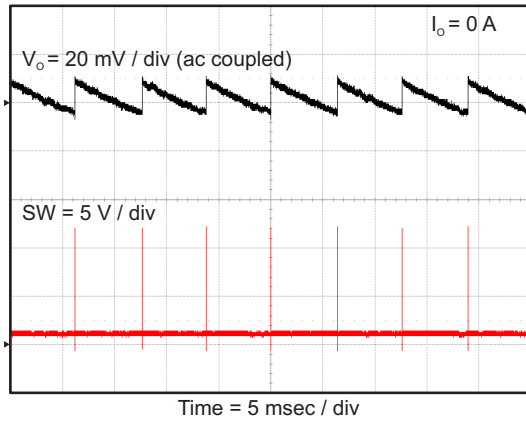
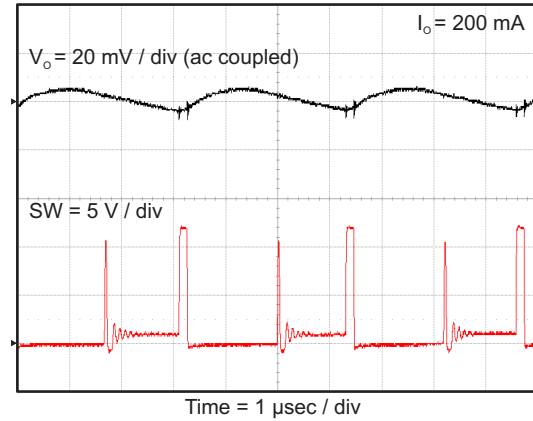


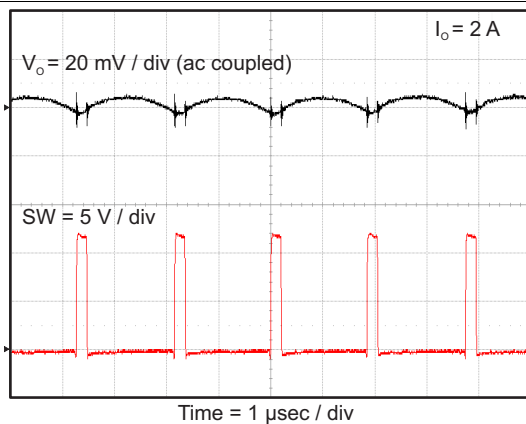
Figure 23. TPS562210A Input Voltage Ripple



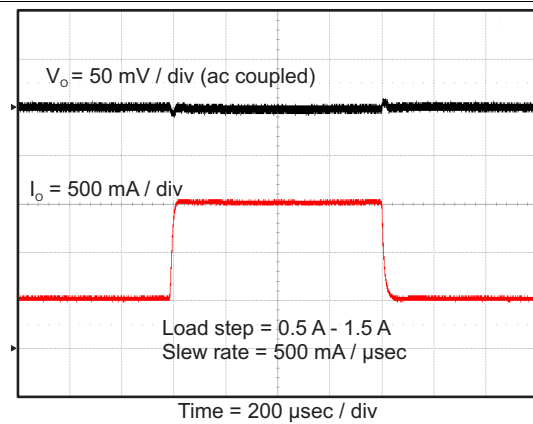
24. TPS562210A Output Voltage Ripple



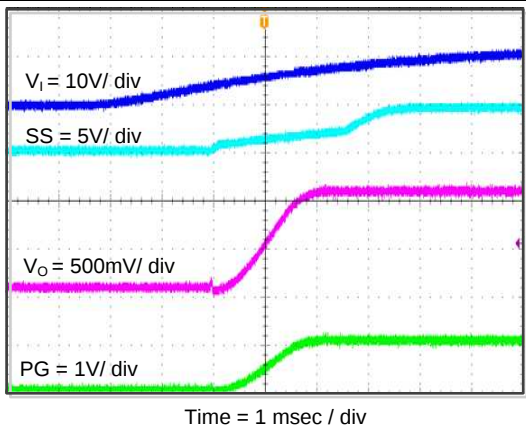
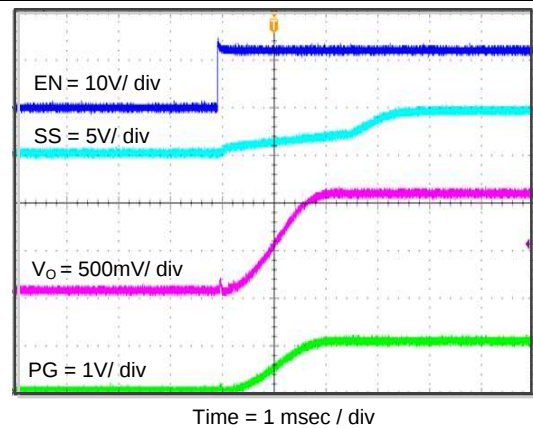
25. TPS562210A Output Voltage Ripple



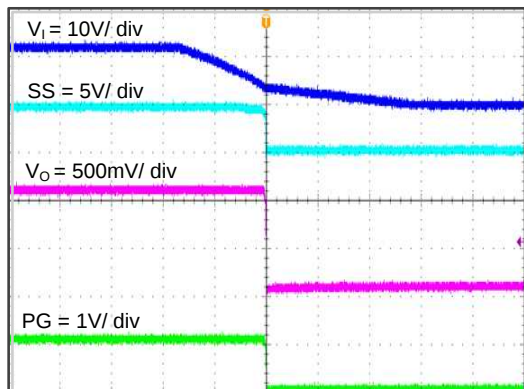
26. TPS562210A Output Voltage Ripple



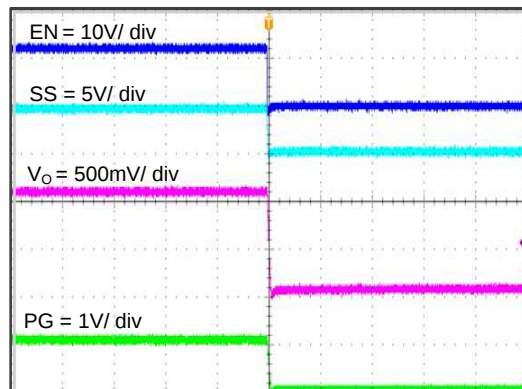
27. TPS562210A Transient Response


 28. TPS562210A Start Up Relative To  $V_i$ 


29. TPS562210A Start Up Relative To En



✎ 30. TPS562210A Shut Down Relative To  $V_I$



✎ 31. TPS562210A Shut Down Relative To EN

## 8.2.2 Typical Application, TPS563210A

4.5-V To 17-V Input, 1.05-V Output Converter.

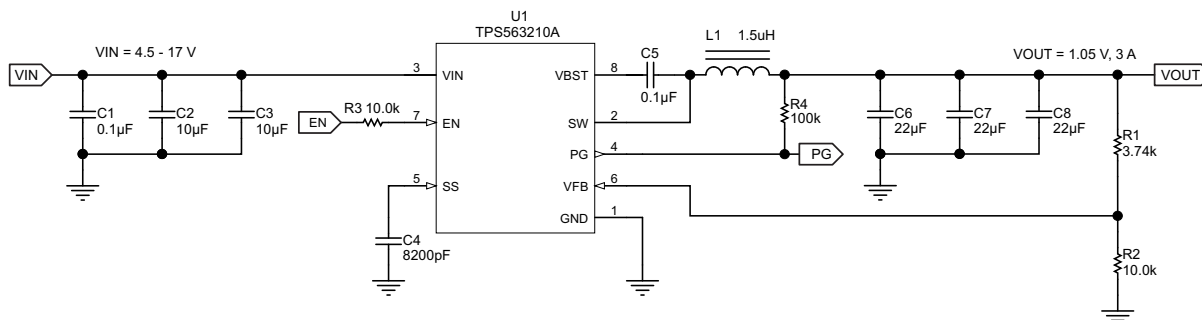


图 32. TPS563210A 1.05 V / 3A Reference Design

### 8.2.2.1 Design Requirements

For this design example, use the parameters shown in 表 3.

表 3. Design Parameters

| PARAMETER             | VALUE         |
|-----------------------|---------------|
| Input voltage range   | 4.5 V to 17 V |
| Output voltage        | 1.05 V        |
| Output current        | 3 A           |
| Output voltage ripple | 20 mVpp       |

### 8.2.2.2 Detailed Design Procedures

The detailed design procedure for TPS563210A is the same as for TPS562210A except for inductor selection.

#### 8.2.2.2.1 Output Filter Selection

表 4. TPS563210A Recommended Component Values

| Output Voltage (V) | R2 (kΩ) | R3 (kΩ) | L1 (µH) |     |     | C6 + C7 + C8 (µF) |
|--------------------|---------|---------|---------|-----|-----|-------------------|
|                    |         |         | MIN     | TYP | MAX |                   |
| 1                  | 3.09    | 10.0    | 1.0     | 1.5 | 4.7 | 20 - 68           |
| 1.05               | 3.74    | 10.0    | 1.0     | 1.5 | 4.7 | 20 - 68           |
| 1.2                | 5.76    | 10.0    | 1.0     | 1.5 | 4.7 | 20 - 68           |
| 1.5                | 9.53    | 10.0    | 1.0     | 1.5 | 4.7 | 20 - 68           |
| 1.8                | 13.7    | 10.0    | 1.5     | 2.2 | 4.7 | 20 - 68           |
| 2.5                | 22.6    | 10.0    | 1.5     | 2.2 | 4.7 | 20 - 68           |
| 3.3                | 33.2    | 10.0    | 1.5     | 2.2 | 4.7 | 20 - 68           |
| 5                  | 54.9    | 10.0    | 2.2     | 3.3 | 4.7 | 20 - 68           |
| 6.5                | 75      | 10.0    | 2.2     | 3.3 | 4.7 | 20 - 68           |

The inductor peak-to-peak ripple current, peak current and RMS current are calculated using 式 9, 式 10 and 式 11. The inductor saturation current rating must be greater than the calculated peak current and the RMS or heating current rating must be greater than the calculated RMS current. Use 650 kHz for  $f_{SW}$ .

Use 650 kHz for  $f_{SW}$ . Make sure the chosen inductor is rated for the peak current of 式 10 and the RMS current of 式 11.

$$I_{P-P} = \frac{V_{OUT}}{V_{IN(MAX)}} \times \frac{V_{IN(MAX)} - V_{OUT}}{L_O \times f_{SW}} \quad (9)$$

$$I_{PEAK} = I_O + \frac{I_{P-P}}{2} \quad (10)$$

$$I_{LO(RMS)} = \sqrt{I_O^2 + \frac{1}{12} I_{P-P}^2} \quad (11)$$

For this design example, the calculated peak current is 3.505 A and the calculated RMS current is 3.014 A. The inductor used is a TDK CLF7045T-1R5N with a peak current rating of 7.3-A and an RMS current rating of 4.9-A.

The capacitor value and ESR determines the amount of output voltage ripple. The TPS563209 is intended for use with ceramic or other low ESR capacitors. Recommended values range from 20  $\mu$ F to 68  $\mu$ F. Use 式 7 to determine the required RMS current rating for the output capacitor. For this design three TDK C3216X5R0J226M 22  $\mu$ F output capacitors are used. The typical ESR is 2 m $\Omega$  each. The calculated RMS current is 0.292A and each output capacitor is rated for 4 A.

### 8.2.2.3 Application Curves

The following application curves were generated using the application circuit of 図 32.

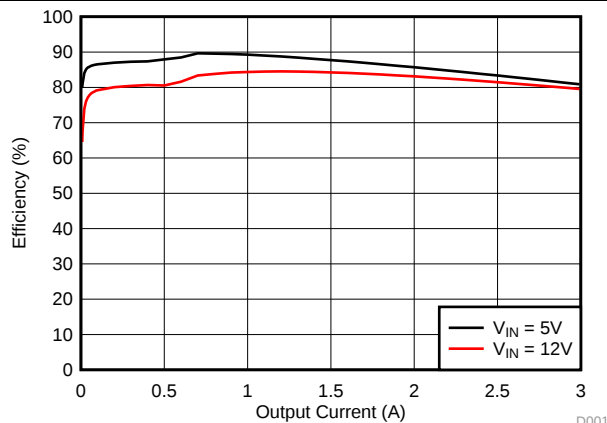


図 33. TPS563210A Efficiency

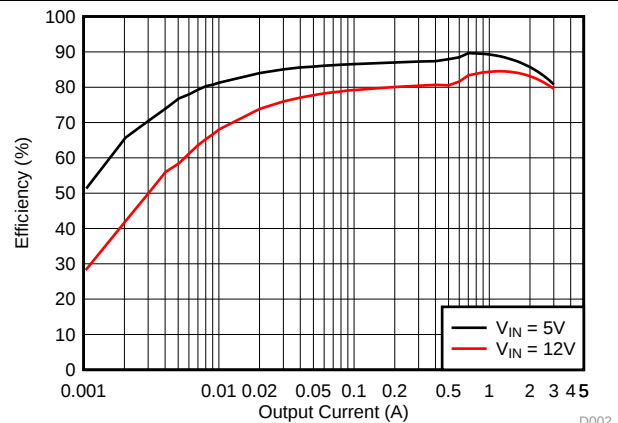


図 34. TPS563210A Light Load Efficiency

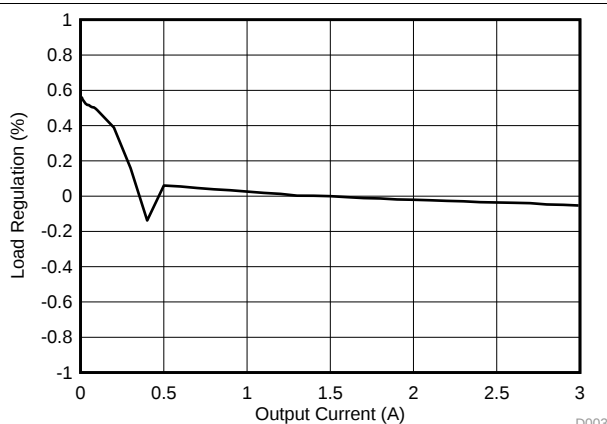


図 35. TPS563210A Load Regulation,  $V_I = 5$  V

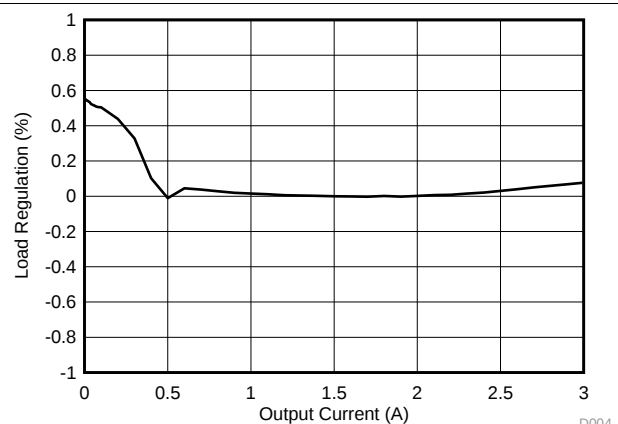


図 36. TPS563210A Load Regulation,  $V_I = 12$  V

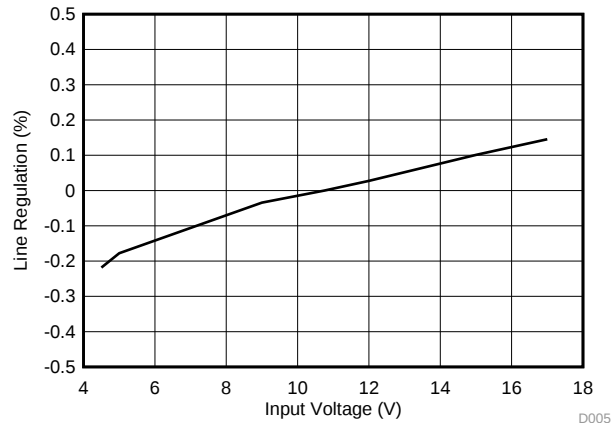


图 37. TPS563210A Line Regulation

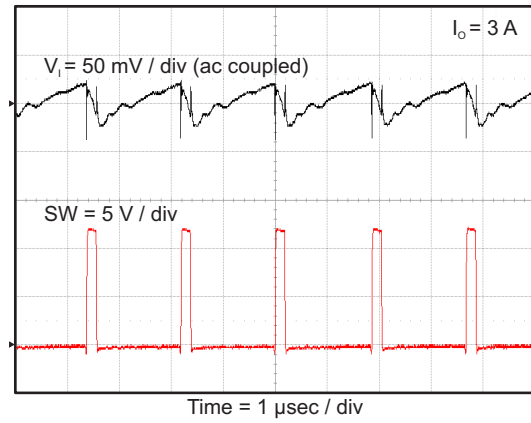


图 38. TPS563210A Input Voltage Ripple

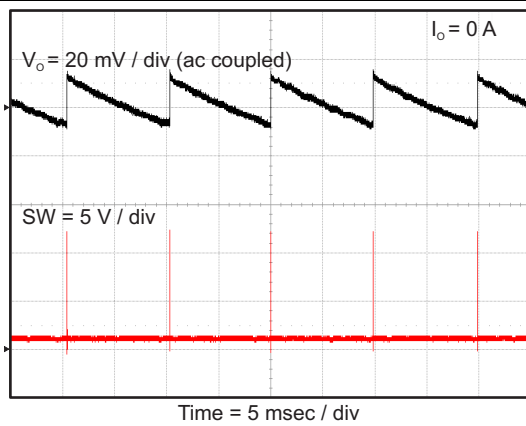


图 39. TPS563210A Output Voltage Ripple

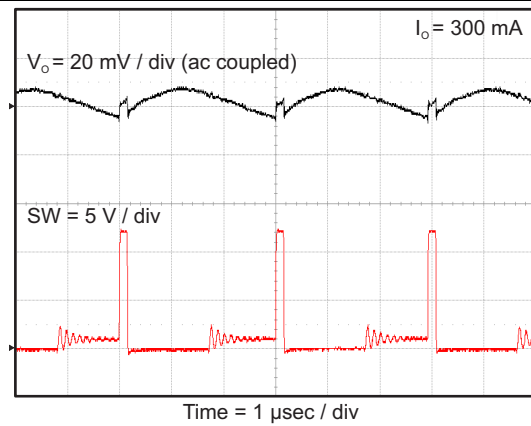


图 40. TPS563210A Output Voltage Ripple

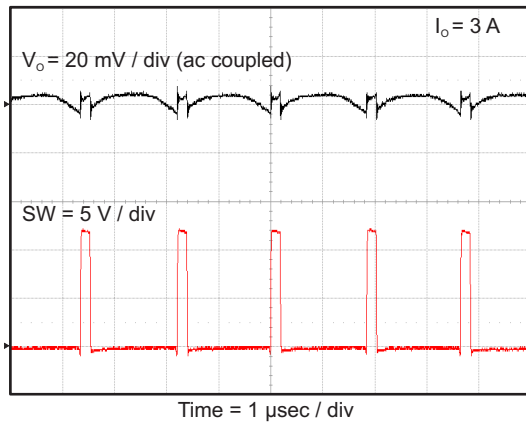


图 41. TPS563210A Output Voltage Ripple

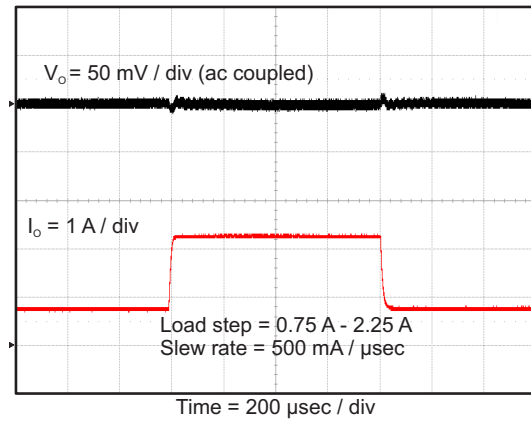
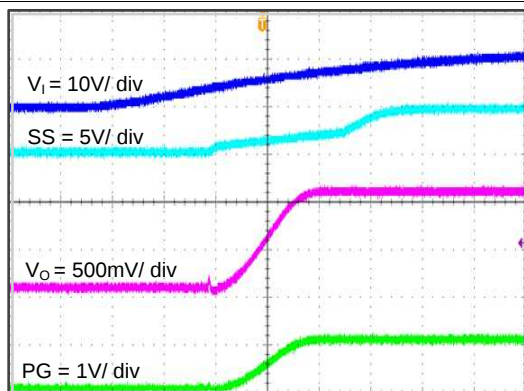
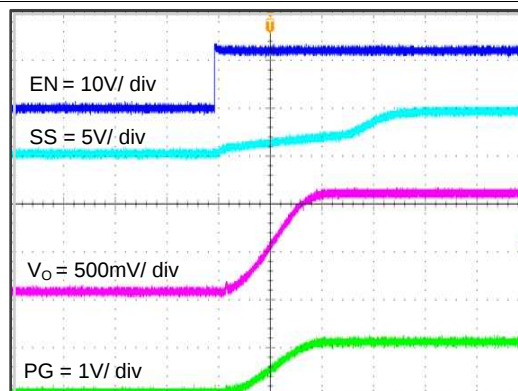


图 42. TPS563210A Transient Response



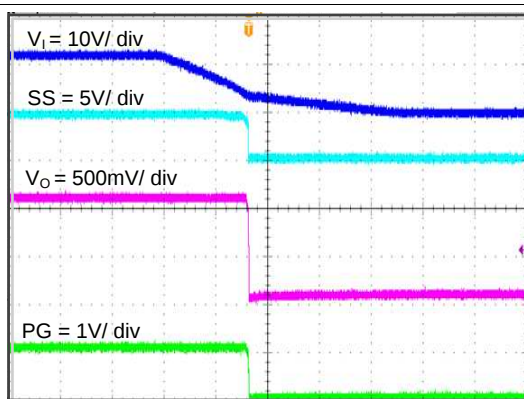
Time = 1 msec / div

图 43. TPS563210A Start Up Relative To  $V_I$



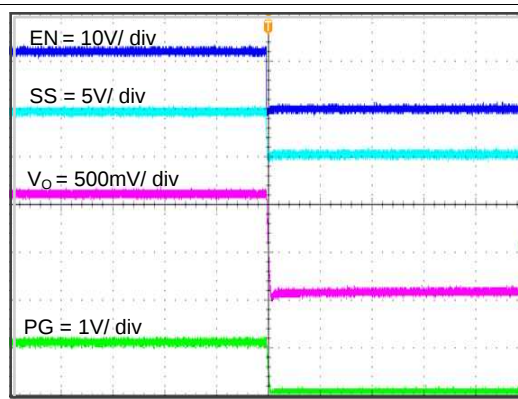
Time = 1 msec / div

图 44. TPS563210A Start Up Relative To EN



Time = 5 msec / div

图 45. TPS563210A Shut Down Relative To  $V_I$



Time = 5 msec / div

图 46. TPS563210A Shut Down Relative To EN

## 9 Power Supply Recommendations

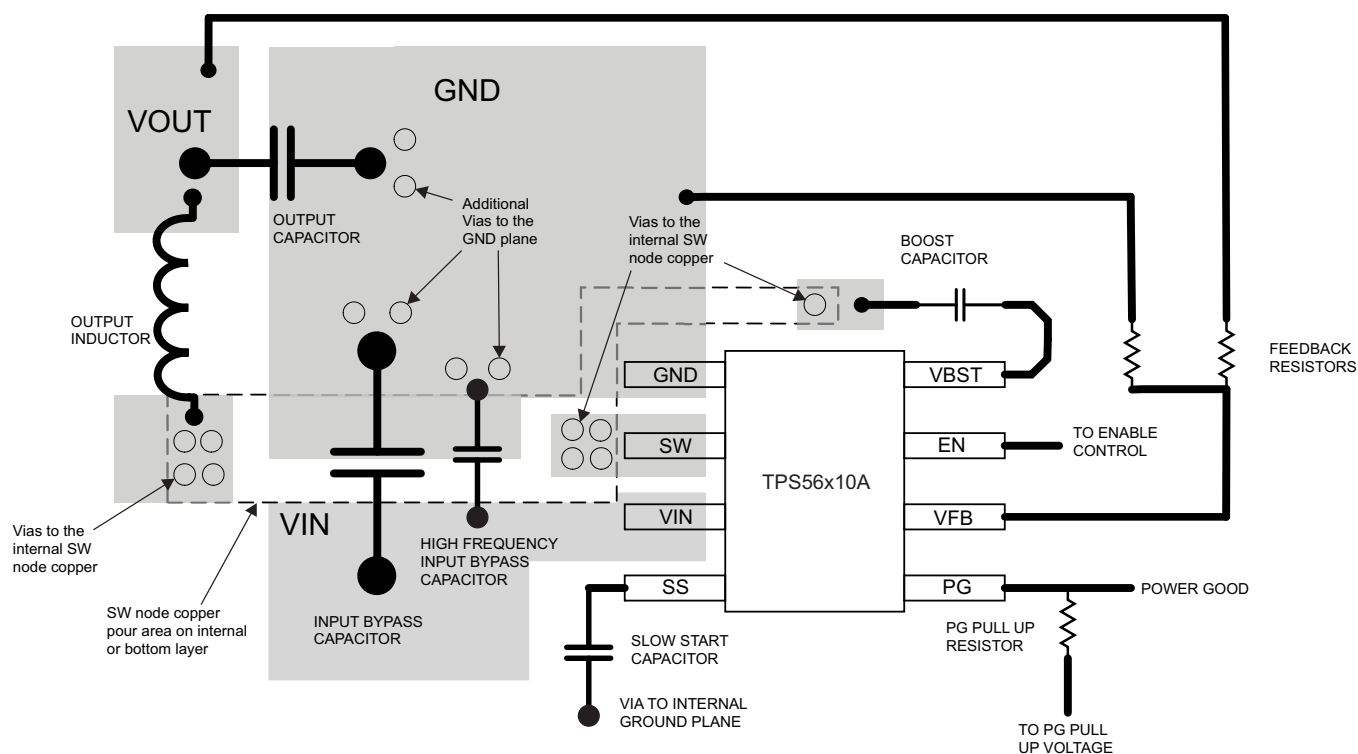
The TPS562210A and TPS563210A are designed to operate from input supply voltage in the range of 4.5 V to 17 V. Buck converters require the input voltage to be higher than the output voltage for proper operation. The maximum recommended operating duty cycle is 65%. Using that criteria, the minimum recommended input voltage is  $V_O / 0.65$ .

## 10 Layout

### 10.1 Layout Guidelines

1. VIN and GND traces should be as wide as possible to reduce trace impedance. The wide areas are also of advantage from the view point of heat dissipation.
2. The input capacitor and output capacitor should be placed as close to the device as possible to minimize trace impedance.
3. Provide sufficient vias for the input capacitor and output capacitor.
4. Keep the SW trace as physically short and wide as practical to minimize radiated emissions.
5. Do not allow switching current to flow under the device.
6. A separate VOUT path should be connected to the upper feedback resistor.
7. Make a Kelvin connection to the GND pin for the feedback path.
8. Voltage feedback loop should be placed away from the high-voltage switching trace, and preferably has ground shield.
9. The trace of the VFB node should be as small as possible to avoid noise coupling.
10. The GND trace between the output capacitor and the GND pin should be as wide as possible to minimize its trace impedance.

### 10.2 Layout Example



## 11 デバイスおよびドキュメントのサポート

### 11.1 デバイス・サポート

### 11.2 関連リンク

次の表に、クイック・アクセス・リンクを示します。カテゴリには、技術資料、サポートおよびコミュニティ・リソース、ツールとソフトウェア、およびサンプル注文またはご購入へのクイック・アクセスが含まれます。

**表 5. 関連リンク**

| 製品         | プロダクト・フォルダ              | サンプルとご購入                | 技術資料                    | ツールとソフトウェア              | サポートとコミュニティ             |
|------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|
| TPS562210A | <a href="#">ここをクリック</a> | <a href="#">ここをクリック</a> | <a href="#">ここをクリック</a> | <a href="#">ここをクリック</a> | <a href="#">ここをクリック</a> |
| TPS563210A | <a href="#">ここをクリック</a> | <a href="#">ここをクリック</a> | <a href="#">ここをクリック</a> | <a href="#">ここをクリック</a> | <a href="#">ここをクリック</a> |

### 11.3 ドキュメントの更新通知を受け取る方法

ドキュメントの更新についての通知を受け取るには、[ti.com](http://ti.com)のデバイス製品フォルダを開いてください。右上の隅にある「通知を受け取る」をクリックして登録すると、変更されたすべての製品情報に関するダイジェストを毎週受け取れます。変更の詳細については、修正されたドキュメントに含まれている改訂履歴をご覧ください。

### 11.4 コミュニティ・リソース

The following links connect to TI community resources. Linked contents are provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's [Terms of Use](#).

**TI E2E™ オンライン・コミュニティ** *TIのE2E ( Engineer-to-Engineer )* コミュニティ。エンジニア間の共同作業を促進するために開設されたものです。e2e.ti.comでは、他のエンジニアに質問し、知識を共有し、アイデアを検討して、問題解決に役立てることができます。

**設計サポート** *TIの設計サポート* 役に立つE2Eフォーラムや、設計サポート・ツールをすばやく見つけることができます。技術サポート用の連絡先情報も参照できます。

### 11.5 商標

D-CAP2, Eco-mode, E2E are trademarks of Texas Instruments.  
Blu-ray Disc is a trademark of Blu-ray Disc Association.

### 11.6 静電気放電に関する注意事項



すべての集積回路は、適切なESD保護方法を用いて、取扱いと保存を行うようにして下さい。

静電気放電はわずかな性能の低下から完全なデバイスの故障に至るまで、様々な損傷を与えます。高精度の集積回路は、損傷に対して敏感であり、極めてわずかなパラメータの変化により、デバイスに規定された仕様に適合しなくなる場合があります。

### 11.7 用語集

**SLYZ022** — *TI用語集*.

この用語集には、用語や略語の一覧および定義が記載されています。

## 12 メカニカル、パッケージ、および注文情報

以降のページには、メカニカル、パッケージ、および注文に関する情報が記載されています。この情報は、そのデバイスについて利用可能な最新のデータです。このデータは予告なく変更されることがあり、ドキュメントが改訂される場合もあります。本データシートのブラウザ版を使用されている場合は、画面左側の説明をご覧ください。

## PACKAGING INFORMATION

| Orderable Device | Status<br>(1) | Package Type | Package<br>Drawing | Pins | Package<br>Qty | Eco Plan<br>(2) | Lead finish/<br>Ball material<br>(6) | MSL Peak Temp<br>(3) | Op Temp (°C) | Device Marking<br>(4/5) | Samples                 |
|------------------|---------------|--------------|--------------------|------|----------------|-----------------|--------------------------------------|----------------------|--------------|-------------------------|-------------------------|
| TPS562210ADDFR   | ACTIVE        | SOT-23-THIN  | DDF                | 8    | 3000           | RoHS & Green    | SN                                   | Level-1-260C-UNLIM   | -40 to 85    | 2210A                   | <a href="#">Samples</a> |
| TPS562210ADDFT   | ACTIVE        | SOT-23-THIN  | DDF                | 8    | 250            | RoHS & Green    | SN                                   | Level-1-260C-UNLIM   | -40 to 85    | 2210A                   | <a href="#">Samples</a> |
| TPS563210ADDFR   | ACTIVE        | SOT-23-THIN  | DDF                | 8    | 3000           | RoHS & Green    | SN                                   | Level-1-260C-UNLIM   | -40 to 85    | 3210A                   | <a href="#">Samples</a> |
| TPS563210ADDFT   | ACTIVE        | SOT-23-THIN  | DDF                | 8    | 250            | RoHS & Green    | SN                                   | Level-1-260C-UNLIM   | -40 to 85    | 3210A                   | <a href="#">Samples</a> |

<sup>(1)</sup> 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.

**OBSELETE:** TI has discontinued the production of the device.

<sup>(2)</sup> **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".

**RoHS Exempt:** TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.

**Green:** TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

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

<sup>(4)</sup> There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

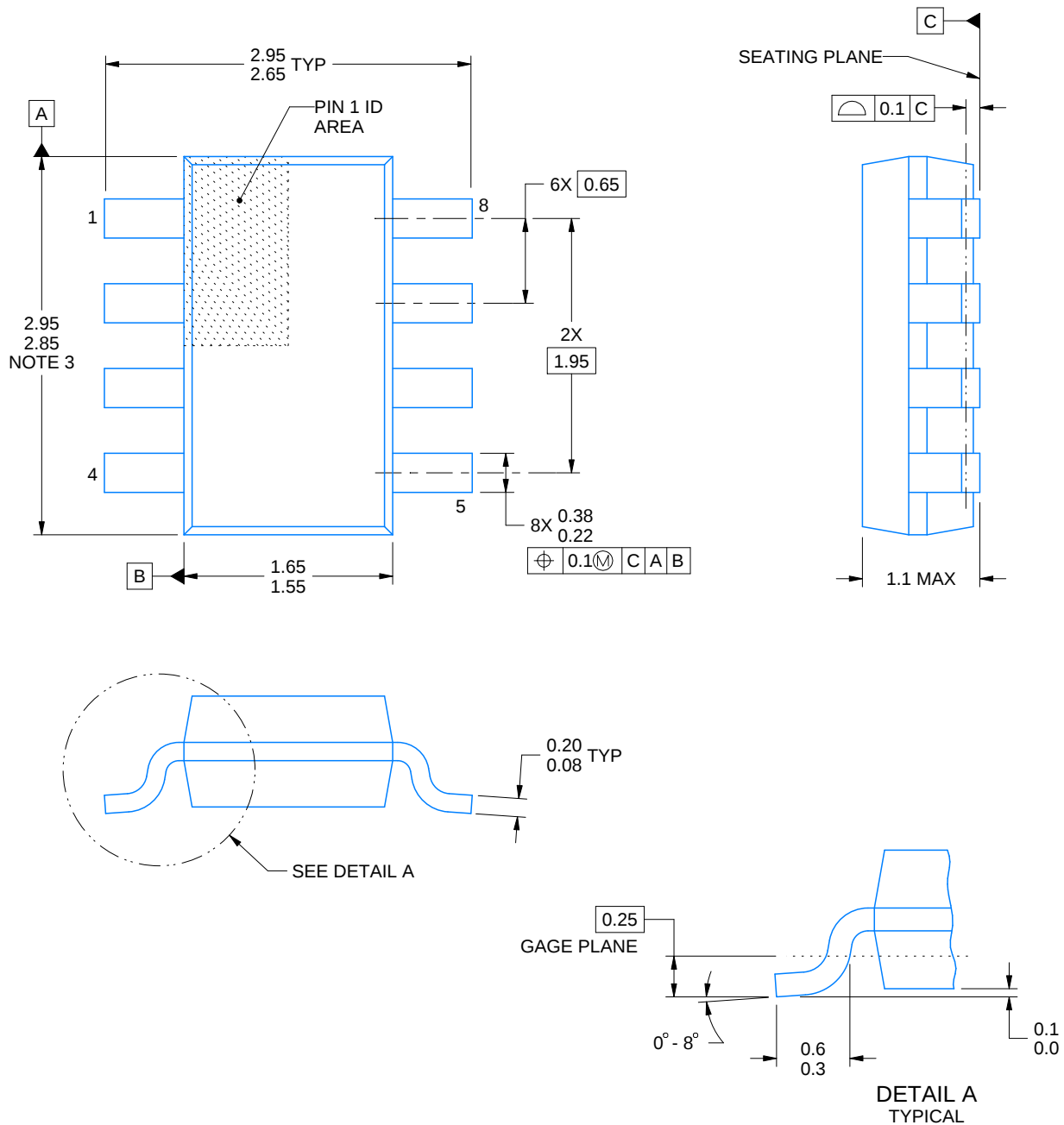
<sup>(5)</sup> Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "-" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

<sup>(6)</sup> Lead finish/Ball material - Orderable Devices 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.

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## NOTES:

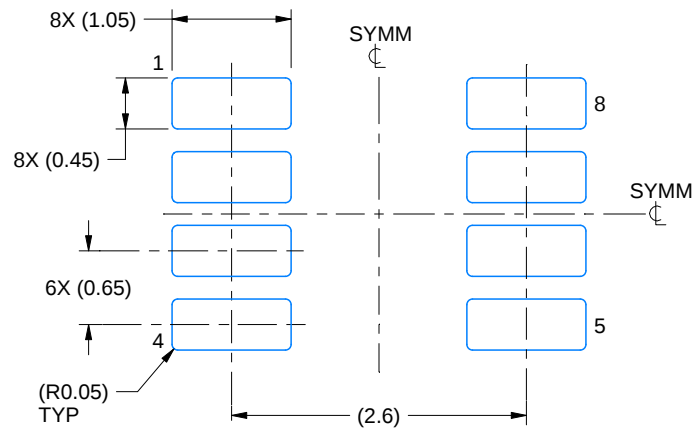
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.

# EXAMPLE BOARD LAYOUT

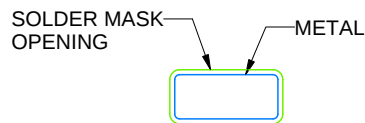
DDF0008A

SOT-23 - 1.1 mm max height

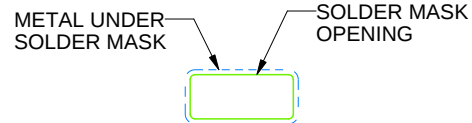
PLASTIC SMALL OUTLINE



LAND PATTERN EXAMPLE  
SCALE:15X



NON SOLDER MASK  
DEFINED



SOLDER MASK  
DEFINED

SOLDER MASK DETAILS

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NOTES: (continued)

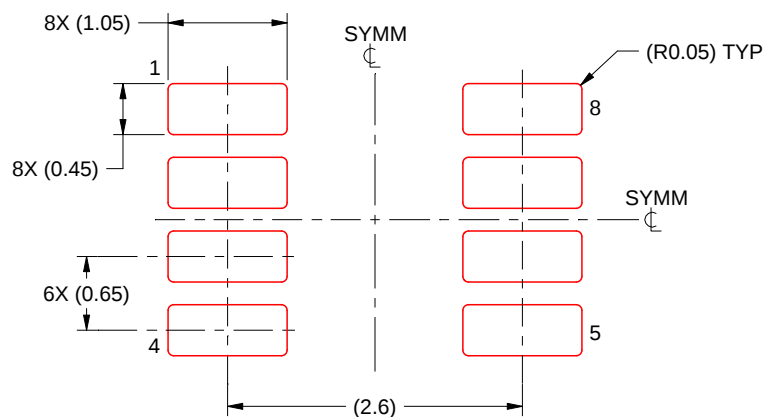
4. Publication IPC-7351 may have alternate designs.
5. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

## EXAMPLE STENCIL DESIGN

DDF0008A

SOT-23 - 1.1 mm max height

PLASTIC SMALL OUTLINE



SOLDER PASTE EXAMPLE  
BASED ON 0.125 mm THICK STENCIL  
SCALE:15X

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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.
7. Board assembly site may have different recommendations for stencil design.

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