TEXAS INSTRUMENTS
TPS62746
JAJSLJ0B – JUNE 2015 – REVISED MARCH 2021

# TPS62746 300/400mA 超低静止電流高効率降圧型コンバータ、VIN スイッチ付き

## 1 特長

- 入力電圧範囲 $V_{IN}$:2.15V～5.5V
- 一度起動した後の入力電圧範囲は最低 2.0V
- 出力電流:300mA
- 動作時静止電流:360nA
- 10μA 出力電流時に最高 90% の効率
- パワーセーブ・モード動作
- 出力電圧を選択可能
  - 1.2V、1.8V
- 出力電圧放電
- 1mA/150Ω の内蔵入力電圧スイッチ
- 低出力電圧リップル
- リップルなし 100% モードへの自動遷移
- RF 対応 DCS-Control™
- 基板占有面積 < 10mm$^2$
- 小型の 1.6mm × 0.9mm 8 ボール WCSP パッケージ

## 2 アプリケーション

- ウェアラブル
- フィットネス・トラッカー
- スマートウォッチ
- 健康状態モニタ
- *Bluetooth*® Low Energy、RF4CE、Zigbee
- 高効率、超低消費電力のアプリケーション
- エネルギー・ハーベスト

## 3 概要

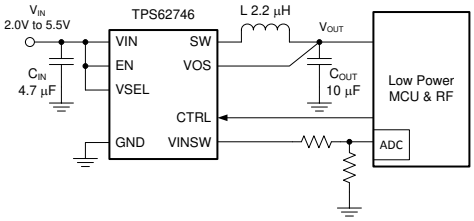
TPS62746 は、静止電流が 360nA (標準値) ときわめて小さい、高効率の降圧型コンバータです。このデバイスは、2.2μH のインダクタと 10μF の出力コンデンサで動作するよう最適化されています。本デバイスは、DCS-Control™ を使用しており、1.2MHz (標準値) のスイッチング周波数で動作します。パワーセーブ・モードでは、10μA 以下の負荷電流範囲まで軽負荷時効率を維持できます。TPS62746 は 300mA の電流を出力します。本デバイスは一度起動すると、最低 2.0V の入力電圧範囲まで動作します。そのため、1 個の Li-$MnO_2$ ボタン型電池で直接動作させることができます。

TPS62746 は、1 本の電圧選択ピンで選択可能な 2 つのプログラマブルな出力電圧 (1.2V と 1.8V) を備えています。 TPS62746 は小さな出力コンデンサだけで、低い出力電圧リップルと低ノイズを実現するよう最適化されています。入力電圧が出力電圧に近づくと、デバイスはリップルなしの 100% モードに移行し、出力リップル電圧の増加を防止します。この動作モードでは、デバイスはスイッチングを停止し、ハイサイドの MOSFET スイッチがオンになります。

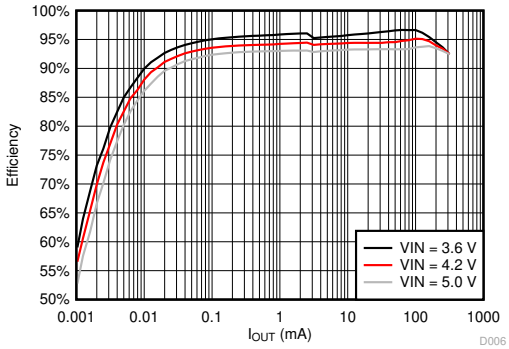
TPS62746 は、VIN ピンの電源電圧を出力 VINSW に接続する 1mA スイッチを内蔵しています。この低電流スイッチを使用して、通常は ADC による入力電圧の測定に使用される入力電源から、抵抗デバイダを切り離すことができます。

**製品情報(1)**

| 部品番号 | パッケージ | 本体サイズ (公称) |
|---|---|---|
| TPS62746 | DSBGA (8) | 1.6mm × 0.9mm |




**代表的なアプリケーション**




英語版の TI 製品についての情報を翻訳したこの資料は、製品の概要を確認する目的で便宜的に提供しているものです。該当する正式な英語版の最新情報は、www.ti.com で閲覧でき、その内容が常に優先されます。TI では翻訳の正確性および妥当性につきましては一切保証いたしません。実際の設計などの前には、必ず最新版の英語版をご参照くださいますようお願いいたします。

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## 4 Revision History

資料番号末尾の英字は改訂を表しています。その改訂履歴は英語版に準じています。

| Changes from Revision A (August 2015) to Revision B (March 2021) | Page |
|---|---|
| • 文書全体にわたって表、図、相互参照の採番方法を更新 | 1 |

| Changes from Revision * (June 2015) to Revision A (August 2015) | Page |
|---|---|
| • Changed $I_{INSW_LEAKAGE}$ spec MAX value from 20 nA to 25 nA | 5 |


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## 5 Device Comparison Table

| $T_A$ | PART NUMBER | OUTPUT VOLTAGE SETTINGS (VSEL 1 - 3) | OUTPUT CURRENT | PACKAGE MARKING |
|---|---|---|---|---|
| –40°C to 85°C | TPS62746 | 1.2 V and 1.8 V (VSEL) | 300 mA | TPS746 |

## 6 Pin Configuration and Functions

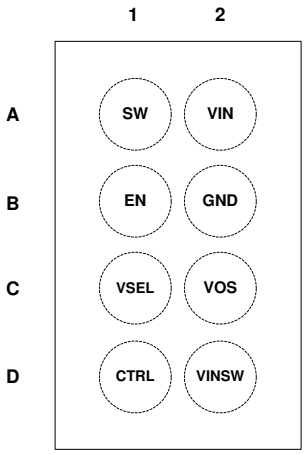



**図 6-1. YFP Package 8-Pin DSBGA Top View**

**表 6-1. Pin Functions**

| PIN | | I/O | DESCRIPTION |
|---|---|---|---|
| NAME | NO | | |
| VIN | A2 | PWR | $V_{IN}$ power supply pin. Connect the input capacitor close to this pin for best noise and voltage spike suppression. A ceramic capacitor of 4.7 µF is required. |
| SW | A1 | OUT | The switch pin is connected to the internal MOSFET switches. Connect the inductor to this terminal. |
| GND | B2 | PWR | GND supply pin. Connect this pin close to the GND terminal of the input and output capacitor. |
| VOS | C2 | IN | Feedback pin for the internal feedback divider network and regulation loop. Discharges $V_{OUT}$ when converter is disabled. Connect this pin directly to the output capacitor with a short trace. |
| VSEL | C1 | IN | Output voltage selection pin. See for $V_{OUT}$ selection. This pin must be terminated. The pin can be dynamically changed during operation. |
| EN | B1 | IN | High level enables the devices, low level turns the device off. The pin must be terminated. |
| CTRL | D1 | IN | This pin controls the input voltage switch between VIN and VINSW. With CTRL = low, the output VINSW is disabled. The pin has an internal 2 MΩ termination to GND. |
| VINSW | D2 | OUT | Output terminal of the input voltage switch. With CTRL = high, the internal switch connects the VINSW pin to the VIN pin. If not used, leave the pin open. |

**表 6-2. Output Voltage Setting TPS62736**

| DEVICE | $V_{OUT}$ | VSEL |
|---|---|---|
| TPS62736 | 1.2 | 0 |
| | 1.8 | 1 |

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# 7 Specifications

## 7.1 Absolute Maximum Ratings

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

| | | MIN | MAX | UNIT |
|---|---|---|---|---|
| Pin voltage(2) | VIN | –0.3 | 6 | V |
| | SW, VSEL, VINSW, CTRL | –0.3 | $V_{IN}$ +0.3V | V |
| | EN | –0.3 | $V_{IN}$ +0.3V | V |
| | VOS | –0.3 | 3.7 | V |
| Operating junction temperature, $T_J$ | | –40 | 125 | °C |
| Storage temperature, $T_{stg}$ | | –65 | 150 | °C |

(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) All voltage values are with respect to network ground terminal GND.

## 7.2 ESD Ratings

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

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process. The human body model is a 100-pF capacitor discharged through a 1.5-kΩ resistor into each pin.
(2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

## 7.3 Recommended Operating Conditions

| | | | MIN | NOM | MAX | UNIT |
|---|---|---|---|---|---|---|
| $V_{IN}$ | Supply voltage $V_{IN}$ | | 2.15 | | 5.5 | V |
| $V_{IN}$ | Supply voltage $V_{IN}$ , once started | | 2.0 | | 5.5 | V |
| $I_{OUT}$ | Device output current | TPS62743 / TPS627431 5.5V ≥ VIN ≥ (VOUTnom + 0.7V) ≥ 2.15V | | | 300 | mA |
| | | 5.5V ≥ VIN ≥ (VOUTnom + 0.7V) ≥ 3V | | | 400 | |
| $T_J$ | Operating junction temperature range | | -40 | | 125 | °C |


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## 7.4 Thermal Information

| THERMAL METRIC[1] | | TPS62746 YFP 8 PINS | UNIT |
|---|---|---|---|
| $R_{\theta JA}$ | Junction-to-ambient thermal resistance | 103 | °C/W |
| $R_{\theta JCtop}$ | Junction-to-case (top) thermal resistance | 1.0 | °C/W |
| $R_{\theta JB}$ | Junction-to-board thermal resistance | 20 | °C/W |
| $\psi_{JT}$ | Junction-to-top characterization parameter | 0.3 | °C/W |
| $\psi_{JB}$ | Junction-to-board characterization parameter | 20 | °C/W |
| $R_{\theta JCbot}$ | Junction-to-case (bottom) thermal resistance | N/A | °C/W |

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

## 7.5 Electrical Characteristics

$V_{IN}$ = 3.6V, $T_A$ = –40°C to 85°C typical values are at $T_A$ = 25°C (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| **SUPPLY** | | | | | | |
| $I_Q$ | Operating quiescent current | EN = $V_{IN}$, CTRL = GND, $I_{OUT}$ = 0µA, $V_{OUT}$ = 1.8V, device not switching | | 360 | 1800 | nA |
| | | EN = $V_{IN}$, $I_{OUT}$ = 0mA, CTRL = GND, $V_{OUT}$ = 1.8V , device switching | | 460 | | |
| $I_{SD}$ | Shutdown current | EN = GND, shutdown current into $V_{IN}$ | | 70 | 1000 | nA |
| $V_{TH_UVLO+}$ | Undervoltage lockout threshold | Rising $V_{IN}$ | | 2.075 | 2.15 | V |
| $V_{TH_UVLO-}$ | | Falling $V_{IN}$ | | 1.925 | 2 | |
| **INPUTS (EN, VSEL, CTRL)** | | | | | | |
| $V_{IH\ TH}$ | High level input threshold | 2.2V ≤ $V_{IN}$ ≤ 5.5V | | | 1.1 | V |
| $V_{IL\ TH}$ | Low level input threshold | 2.2V ≤ $V_{IN}$ ≤ 5.5V | 0.4 | | | V |
| $I_{IN}$ | Input bias Current | | | 10 | 25 | nA |
| **POWER SWITCHES** | | | | | | |
| $R_{DS(ON)}$ | High side MOSFET on-resistance | $I_{OUT}$ = 50mA | | 0.45 | 1.12 | Ω |
| | Low Side MOSFET on-resistance | | | 0.22 | 0.65 | |
| $I_{LIMF}$ | High side MOSFET switch current limit | | 480 | 600 | 720 | mA |
| | | | 590 | 650 | 800 | |
| | Low side MOSFET switch current limit | TPS62743 | | 600 | | |
| | | TPS627431 | | 650 | | |
| **OUTPUT VOLTAGE DISCHARGE** | | | | | | |
| $R_{DSCH_VOS}$ | MOSFET on-resistance | EN = GND, $I_{VOS}$ = -10mA into VOS pin | | 30 | 65 | Ω |
| $I_{IN_VOS}$ | Bias current into VOS pin | EN = $V_{IN}$, $V_{OUT}$ = 2V | | 40 | 1010 | nA |
| **INPUT VOLTAGE SWITCH (VINSW)** | | | | | | |
| $R_{RDSON}$ | MOSFET on-resistance | $I_{VINSW}$ = 1mA, CTRL = $V_{IN}$, VIN = 2.1V | | | 150 | Ω |
| $I_{INSW_LEAKAGE}$ | VIN-switch leakage | CTRL = GND, leakage fron VIN to VINSW when pulled to GND | | | 25 | nA |
| $I_{INSW}$ | VIN-switch current | | 5 | | 36 | mA |

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$V_{IN}$ = 3.6V, $T_A$ = –40°C to 85°C typical values are at $T_A$ = 25°C (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| **AUTO 100% MODE TRANSITION** | | | | | | |
| $V_{TH_100+}$ | Auto 100% Mode leave detection threshold (1) | Rising $V_{IN}$,100% Mode is left with $V_{IN}$ = $V_{OUT}$ + $V_{TH_100+}$ | 150 | 250 | 350 | mV |
| $V_{TH_100-}$ | Auto 100% Mode enter detection threshold (1) | Falling $V_{IN}$, 100% Mode is entered with $V_{IN}$ = $V_{OUT}$ + $V_{TH_100-}$ | 85 | 200 | 290 | |
| **OUTPUT** | | | | | | |
| $I_{LIM_softstart}$ | High side softstart switch current limit | EN=low to high | 80 | 150 | 200 | mA |
| | Low side softstart switch current limit | | | 150 | | |
| $V_{OUT}$ | Output voltage range | Output voltages are selected with pins VSEL | 1.2 | | 1.8 | V |
| | Output voltage accuracy | $I_{OUT}$ = 10mA, $V_{OUT}$ = 1.8V | -2.5 | 0% | 2.5 | |
| | | $I_{OUT}$ = 100mA, $V_{OUT}$ = 1.8V | –2 | 0% | 2 | |
| | DC output voltage load regulation | $V_{OUT}$ = 1.8V | | 0.001 | | %/mA |
| | DC output voltage line regulation | $V_{OUT}$ = 1.8V, $I_{OUT}$ = 100mA, 2.2V ≤ $V_{IN}$ ≤ 5.0V | | 0 | | %/V |

(1) $V_{IN}$ is compared to the programmed output voltage ($V_{OUT}$). When $V_{IN}$–$V_{OUT}$ falls below $V_{TH_100-}$ the device enters 100% Mode by turning the high side MOSFET on. The 100% Mode is exited when $V_{IN}$–$V_{OUT}$ exceeds $V_{TH_100+}$ and the device starts switching. The hysteresis for the 100% Mode detection threshold $V_{TH_100+}$ - $V_{TH_100-}$ will always be positive and will be approximately 50 mV(typ)

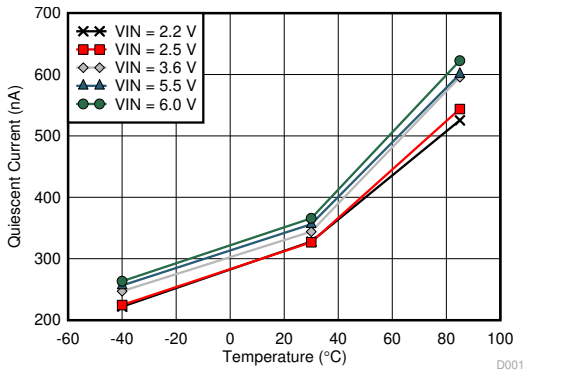
## 7.6 Timing Requirements

$V_{IN}$ = 3.6V, $T_J$ = –40°C to 85°C typical values are at $T_A$ = 25°C (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| **OUTPUT** | | | | | | |
| $t_{ONmin}$ | Minimum ON time | $V_{OUT}$ = 2.0V, $I_{OUT}$ = 0 mA | | 225 | | ns |
| $t_{OFFmin}$ | Minimum OFF time | $V_{IN}$ = 2.3V | | 50 | | ns |
| $t_{Startup_delay}$ | Regulator start up delay time | From transition EN = low to high until device starts switching | | 10 | 25 | ms |
| $t_{Softstart}$ | Softstart time | 2.2V ≤ $V_{IN}$ ≤ 5.5V, EN = $V_{IN}$ | | 700 | 1200 | µs |

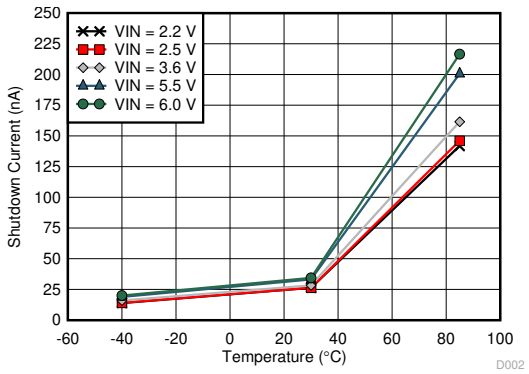

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## 7.7 Typical Characteristics




EN = VIN, $V_{OUT}$ = 1.8V  Device Not Switching

**図 7-1. Quiescent Current vs Temperature**




EN = GND

**図 7-2. Shutdown Current $I_{SD}$ vs Temperature**

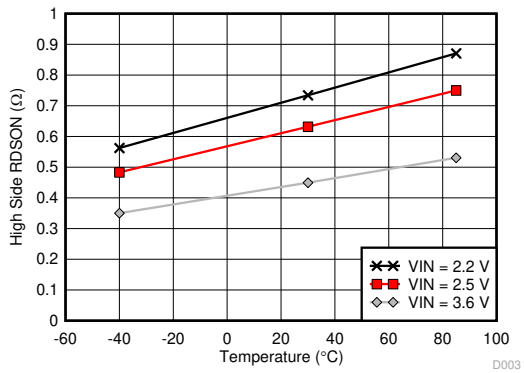



**図 7-3. High Side $R_{DSON}$ vs Temperature**

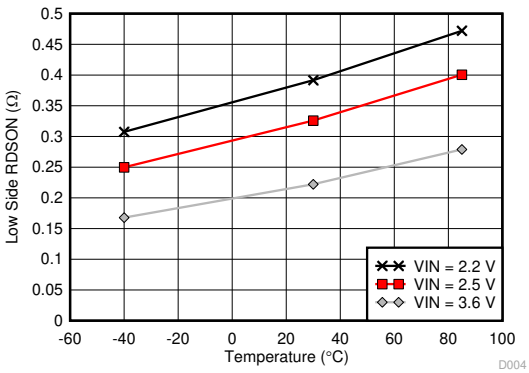



**図 7-4. Low-side $R_{DSON}$ vs Temperature**

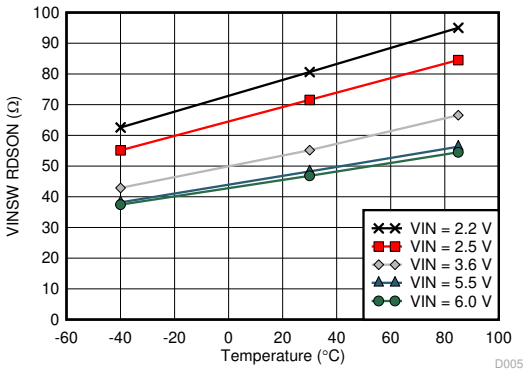



**図 7-5. VINSW $R_{DSON}$ vs Temperature**

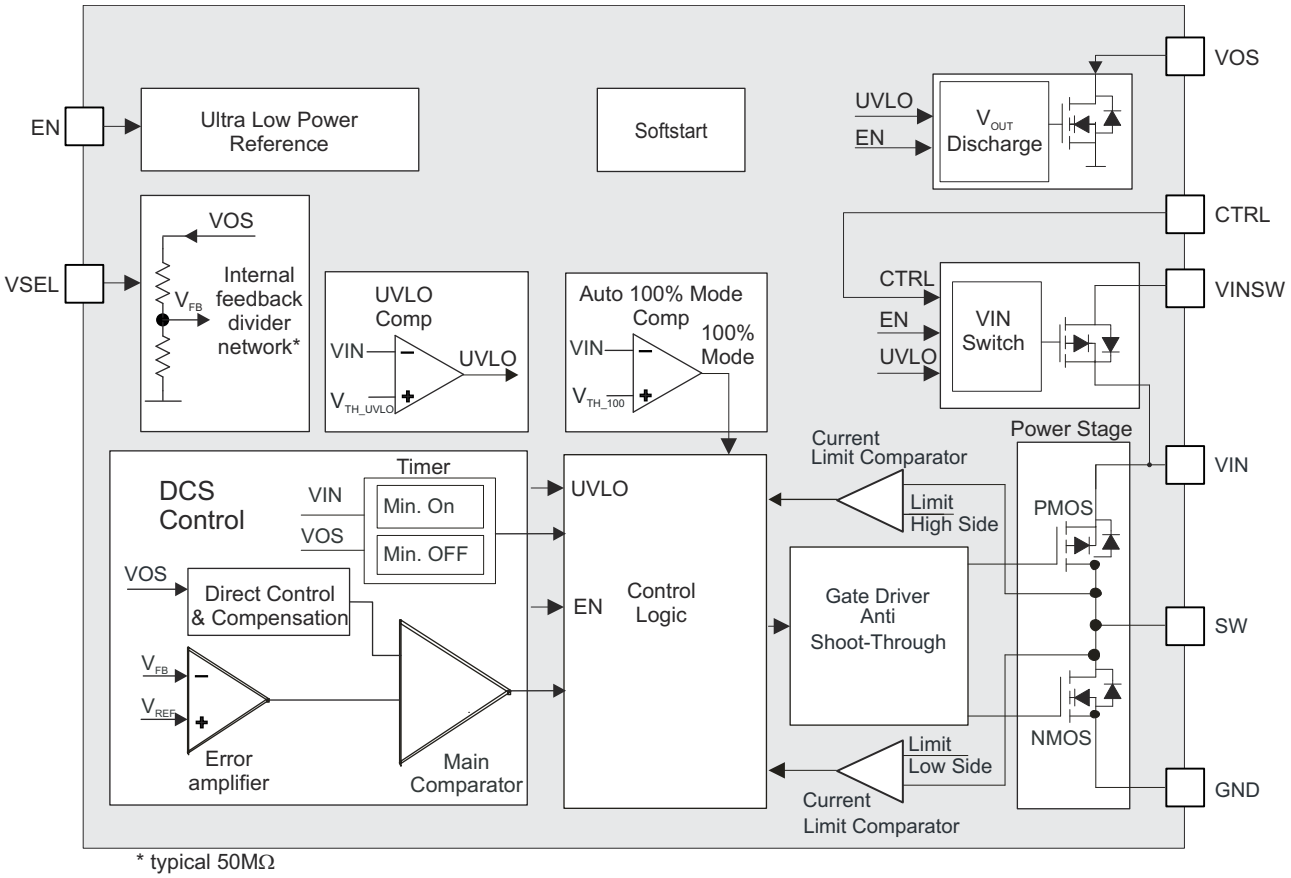
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# 8 Detailed Description

## 8.1 Overview

The TPS62746 is a high frequency step down converter with ultra low quiescent current. The device operates with a quasi fixed switching frequency typically at 1.2 MHz. Using TI's DCS-Control™ topology the device extends the high efficiency operation area down to a few microamperes of load current during Power Save Mode Operation.

## 8.2 Functional Block Diagram




* typical 50MΩ

## 8.3 Feature Description

### 8.3.1 DCS-Control™

TI's DCS-Control™ (Direct Control with Seamless Transition into Power Save Mode) is an advanced regulation topology, which combines the advantages of hysteretic and voltage mode control. Characteristics of DCS-Control™ are excellent AC load regulation and transient response, low output ripple voltage and a seamless transition between PFM and PWM mode operation. DCS-Control™ includes an AC loop which senses the output voltage (VOS pin) and directly feeds the information to a fast comparator stage. This comparator sets the switching frequency, which is constant for steady state operating conditions, and provides immediate response to dynamic load changes. In order to achieve accurate DC load regulation, a voltage feedback loop is used. The internally compensated regulation network achieves fast and stable operation with small external components and low ESR capacitors.

The DCS-Control™ topology supports PWM (Pulse Width Modulation) mode for medium and high load conditions and a Power Save Mode at light loads. During PWM mode, it operates in continuous conduction mode. The switching frequency is typically 1.2 MHz with a controlled frequency variation depending on the input voltage and load current. If the load current decreases, the converter seamlessly enters Power Save Mode to maintain high efficiency down to very light loads. In Power Save Mode, the switching frequency varies linearly


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with the load current. Since DCS-Control™ supports both operation modes within one single building block, the transition from PWM to Power Save Mode is seamless with minimum output voltage ripple. The TPS62746 offers both excellent DC voltage and superior load transient regulation, combined with low output voltage ripple, minimizing interference with RF circuits.

### 8.3.2 Power Save Mode Operation

In Power Save Mode the device operates in PFM (Pulse Frequency Modulation) that generates a single switching pulse to ramp up the inductor current and recharges the output capacitor, followed by a sleep period where most of the internal circuits are shutdown to achieve lowest operating quiescent current. During this time, the load current is supported by the output capacitor. The duration of the sleep period depends on the load current and the inductor peak current. During the sleep periods, the current consumption of TPS62746 is reduced to 360 nA. This low quiescent current consumption is achieved by an ultra low power voltage reference, an integrated high impedance feedback divider network and an optimized Power Save Mode operation.

### 8.3.3 1mA VIN Switch

The VIN switch connects the VIN pin with the VINSW pin with a maximum on-resistance of 150 Ω. This switch can be used to disconnect the input supply from a resistor divider typically used with an ADC measuring the input or battery voltage. The input switch is capable of driving 1 mA current. The switch has a short circuit protection with a minimum current limit of 5 mA. The VIN switch operates device independent and is not turned off by the device enable, EN. The switch operates down to the device undervoltage lockout threshold but is not turned off by the undervoltage lockout. Therefore the CTRL pin needs to be terminated and not left floating.

### 8.3.4 Output Voltage Selection

The TPS62746 doesn't require an external resistor divider network to program the output voltage. The device integrates a high impedance feedback resistor divider network that is programmed by the pin VSEL. TPS62746 supports two output voltage options: 1.2 V and 1.8 V. The output voltage is programmed according to 表 6-2. The output voltage can be changed during operation. This can be used for simple dynamic output voltage scaling.

### 8.3.5 Output Voltage Discharge of the Buck Converter

The device provides automatic output voltage discharge when EN is pulled low or the UVLO is triggered. The output of the buck converter is discharged over VOS. Because of this the output voltage will ramp up from zero once the device is enabled again. This is very helpful for accurate start-up sequencing.

### 8.3.6 Undervoltage Lockout UVLO

To avoid misoperation of the device at low input voltages, an undervoltage lockout is used. The UVLO shuts down the device at a maximum voltage level of 2.0 V. The device will start at a UVLO level of 2.15 V.

### 8.3.7 Short circuit protection

The TPS6274x integrates a current limit on the high side, as well on the low side MOSFETs to protect the device against overload or short circuit conditions. The peak current in the switches is monitored cycle by cycle. If the high side MOSFET current limit is reached, the high side MOSFET is turned off and the low side MOSFET is turned on until the switch current decreases below the low side MOSFET current limit. Once the low side MOSFET current limit trips, the low side MOSFET is turned off and the high side MOSFET turns on again.

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## 8.4 Device Functional Modes

### 8.4.1 Enable and Shutdown

The device is turned on with EN=high. With EN=low the device enters shutdown and turns off the VIN switch . This pin must be terminated.

### 8.4.2 Device Start-up and Softstart

The device has an internal softstart to minimize input voltage drop during start-up. This allows the operation from high impedance battery cells. Once the device is enabled the device starts switching after a typical delay time of 10ms. Then the softstart time of typical 700 µs begins with a reduced current limit of typical 150 mA. When this time passed by the device enters full current limit operation. This allows a smooth start-up and the device can start into full load current. Furthermore, larger output capacitors impact the start-up behaviour of the DC/DC converter. Especially when the output voltage does not reach its nominal value after the typical soft-start time of 700 µs, has passed.

### 8.4.3 Automatic Transition Into No Ripple 100% Mode

Once the input voltage comes close to the output voltage, the DC/DC converter stops switching and enters 100% duty cycle operation. It connects the output $V_{OUT}$ via the inductor and the internal high side MOSFET switch to the input VIN, once the input voltage $V_{IN}$ falls below the 100% mode enter threshold, $V_{TH_100-}$. The DC/DC regulator is turned off, switching stops and therefore no output voltage ripple is generated. Since the output is connected to the input, the output voltage follows the input voltage minus the voltage drop across the internal high side switch and the inductor. Once the input voltage increases and trips the 100% mode exit threshold, $V_{TH_100+}$ , the DC/DC regulator turns on and starts switching again. See 図 8-1 and 図 9-20.

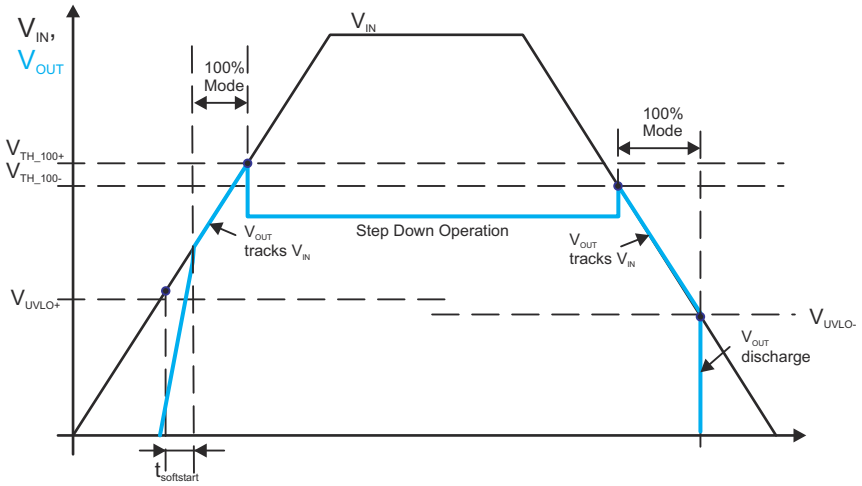



**図 8-1. Automatic Transition into 100% Mode**


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# 9 Application and Implementation

注

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## 9.1 Application Information

The TPS62746 is a high efficiency step down converter with ultra low quiescent current of typically 360 nA. The device operates with a tiny 2.2-µH inductor and 10-µF output capacitor over the entire recommended operation range. A dedicated measurement set-up is required for the light load efficiency measurement and device quiescent current due to the operation in the sub microampere range. In this range any leakage current in the measurement set-up will impact the measurement results.

## 9.2 Typical Application

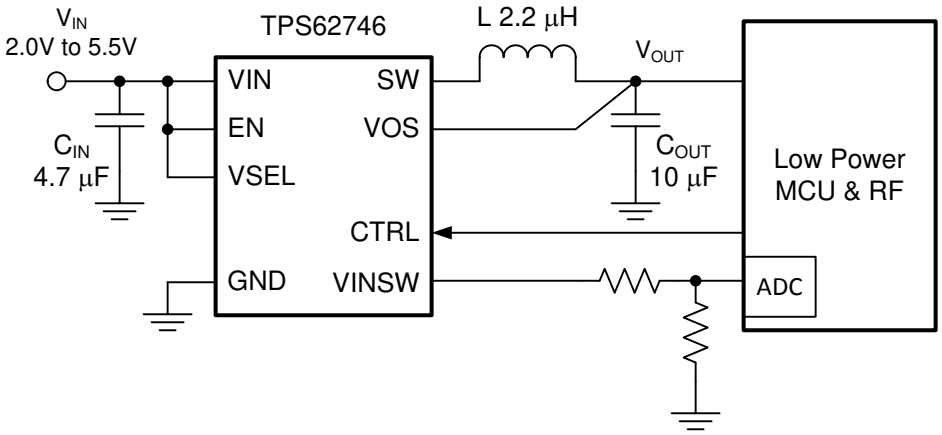



**図 9-1. TPS62746 Typical Application Circuit**

### 9.2.1 Design Requirements

The TPS62746 is a highly integrated DC/DC converter. The output voltage is set via a VSEL pin interface. The design guideline provides a component selection to operate the device within the recommended operating conditions.

表 9-1 shows the list of components for the Application Characteristic Curves.

**表 9-1. Components for Application Characteristic Curves**

| Reference | Description | Value | Manufacturer |
|---|---|---|---|
| TPS62746 | 360nA Iq step down converter | | Texas Instruments |
| CIN | Ceramic capacitor, GRM155R61C475ME15 | 4.7 µF | Murata |
| COUT | Ceramic capacitor, GRM155R60J106ME11 | 10 µF | Murata |
| L | Inductor DFE201610C | 2.2 µH | Toko |

### 9.2.2 Detailed Design Procedure

The first step in the design procedure is the selection of the output filter components. To simplify this process, 表 9-2 outlines possible inductor and capacitor value combinations.

**表 9-2. Recommended LC Output Filter Combinations**

| Inductor Value [µH](2) | Output Capacitor Value [µF](1) | | | | |
|---|---|---|---|---|---|
| | 4.7µF | 10µF | 22µF | 47µF | 100µF |
| 2.2 | √ | √(3) | √ | √ | |

(1) Capacitance tolerance and bias voltage de-rating is anticipated. The effective capacitance varies by +20% and –50%.
(2) Inductor tolerance and current de-rating is anticipated. The effective inductance can vary by 20% and -30%.
(3) Typical application configuration. Other check marks indicate alternative filter combinations.

#### *9.2.2.1 Inductor Selection*

The inductor value affects the peak-to-peak ripple current, the PWM-to-PFM transition point, the output voltage ripple and the efficiency. The selected inductor has to be rated for its DC resistance and saturation current. The inductor ripple current ($\Delta I_L$) decreases with higher inductance and increases with higher $V_{IN}$ or $V_{OUT}$ and can be estimated according to 式 1.

式 2 calculates the maximum inductor current under static load conditions. The saturation current of the inductor should be rated higher than the maximum inductor current, as calculated with equation 2. This is recommended because during a heavy load transient the inductor current rises above the calculated value. A more conservative way is to select the inductor saturation current according to the high-side MOSFET switch current limit, $I_{LIMF}$.

$$\Delta I_L = Vout \times \frac{1 - \frac{Vout}{Vin}}{L \times f} \quad (1)$$

$$I_{Lmax} = I_{outmax} + \frac{\Delta I_L}{2} \quad (2)$$

where

- f = Switching Frequency
- L = Inductor Value
- $\Delta I_L$= Peak to Peak inductor ripple current
- $I_{Lmax}$ = Maximum Inductor current

表 9-3 shows a list of possible inductors.


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**表 9-3. List of Possible Inductors**(1)

| INDUCTANCE [µH] | DIMENSIONS [mm³] | INDUCTOR TYPE | Isat/DCR | SUPPLIER | Comment |
|---|---|---|---|---|---|
| 2.2 | 2.0 x 1.6 x 1.0 | DFE201610C | 1.4 A/170 mΩ | TOKO | Efficiency plot 図 9-8 |
| 2.2 | 2.0 × 1.25 × 1.0 | MIPSZ2012D 2R2 | 0.7 A/230 mΩ | FDK | |
| 2.2 | 2.0 x 1.2 x 1.0 | 744 797 752 22 | 0.7 A/200 mΩ | Würth Elektronik | |
| 2.2 | 1.6 x 0.8 x 0.8 | MDT1608-CH2R2M | 0.7 A/300 mΩ | TOKO | |

(1) See *セクション 12.1*

#### *9.2.2.2 Output Capacitor Selection*

The DCS-Control™ scheme of the TPS62746 allows the use of tiny ceramic capacitors. Ceramic capacitors with low ESR values have the lowest output voltage ripple and are recommended. The output capacitor requires either an X7R or X5R dielectric. At light load currents, the converter operates in Power Save Mode and the output voltage ripple is dependent on the output capacitor value. A larger output capacitors can be used reducing the output voltage ripple. The leakage current of the output capacitor adds to the overall quiescent current.

#### *9.2.2.3 Input Capacitor Selection*

Because the buck converter has a pulsating input current, a low ESR input capacitor is required for best input voltage filtering to minimize input voltage spikes. For most applications a 4.7-µF input capacitor is sufficient. When operating from a high impedance source, like a coin cell a larger input buffer capacitor ≥10uF is recommended avoiding voltage drops during start-up and load transients. The input capacitor can be increased without any limit for better input voltage filtering. The leakage current of the input capacitor adds to the overall quiescent current. 表 9-4 shows a selection of input and output capacitors.

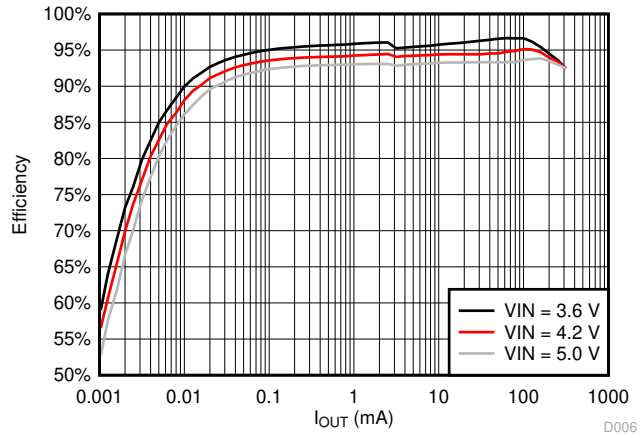
**表 9-4. List of Possible Capacitors**(1)

| CAPACITANCE [µF] | SIZE | CAPACITOR TYPE | SUPPLIER |
|---|---|---|---|
| 4.7 | 0402 | GRM155R61C475ME15 | Murata |
| 10 | 0402 | GRM155R60J106ME11 | Murata |

(1) See *Third-party Products Disclaimer*

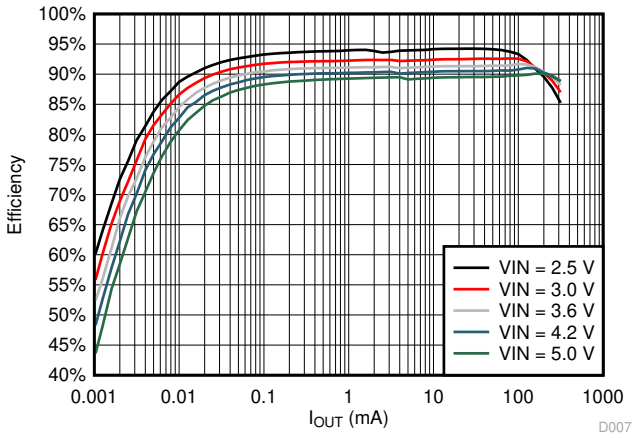
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### 9.2.3 Application Curves



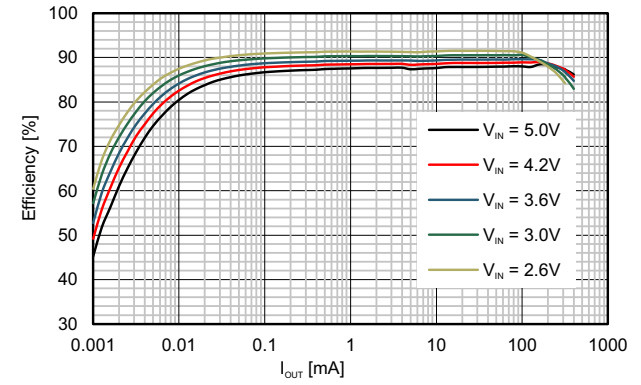

TPS62743

**図 9-2. Efficiency vs Load Current, $V_{OUT}$ = 3.3 V**



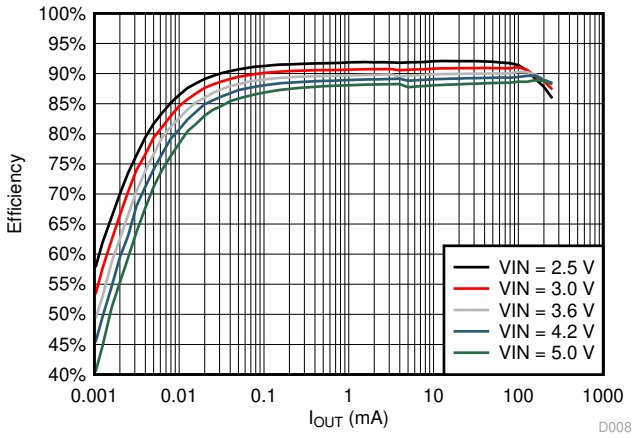

TPS62743

**図 9-3. Efficiency vs Load Current; $V_{OUT}$ = 2.1 V**



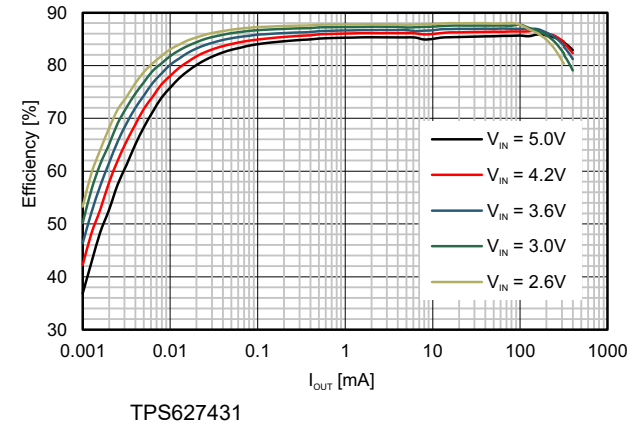

TPS627431

**図 9-4. Efficiency vs Load Current; $V_{OUT}$ = 1.9 V**



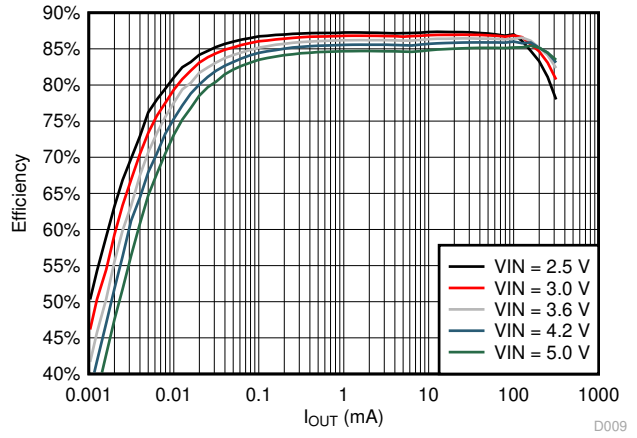

TPS62743

**図 9-5. Efficiency vs Load Current; VOUT = 1.8 V**




TPS627431

**図 9-6. Efficiency vs Load Current; VOUT = 1.4 V**




TPS62743

**図 9-7. Efficiency vs Load Current; $V_{OUT}$ = 1.2 V**


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### 9.2.3 Application Curves (continued)

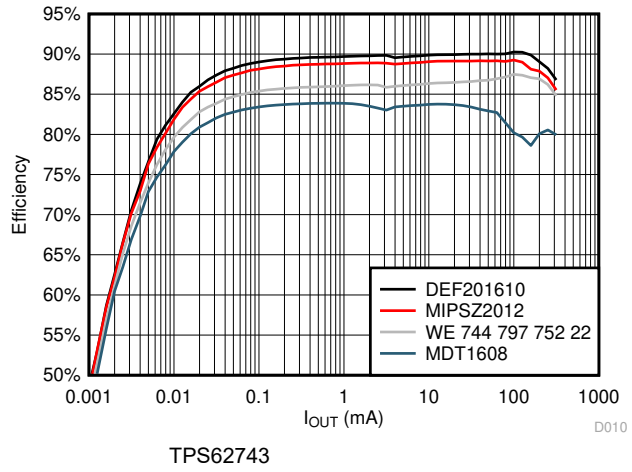



**図 9-8. Efficiency vs Load Current; $V_{OUT}$ = 1.8 V**

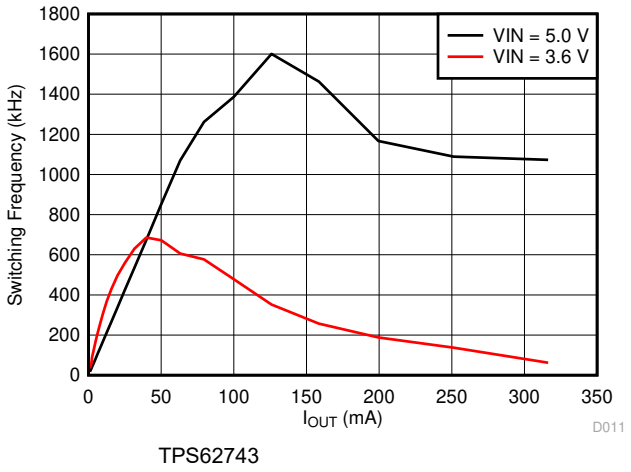



**図 9-9. Switching Frequency vs Load Current $V_{OUT}$ = 3.3 V**

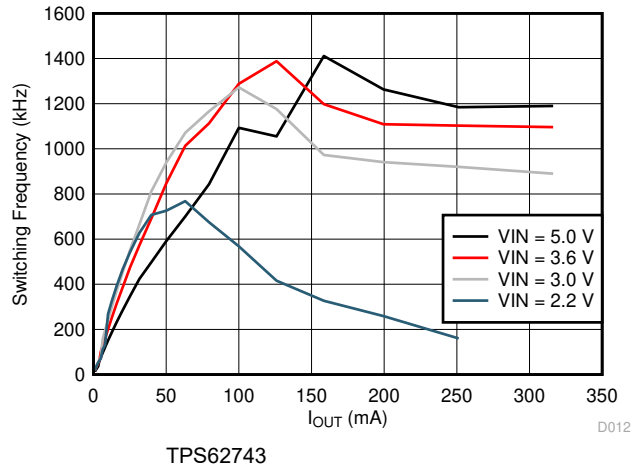



**図 9-10. Switching Frequency vs Load Current $V_{OUT}$ = 1.8 V**

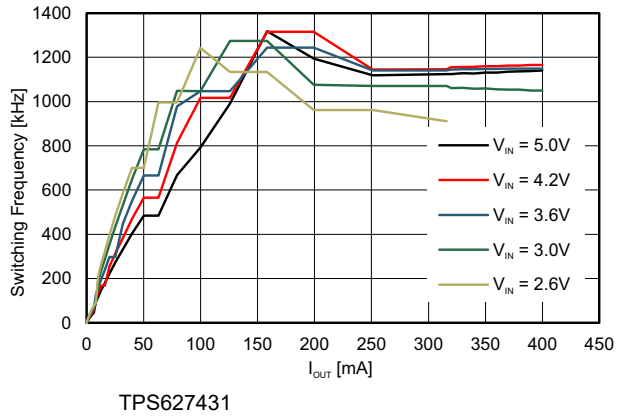



**図 9-11. Switching Frequency vs Load Current $V_{OUT}$ = 1.4 V**

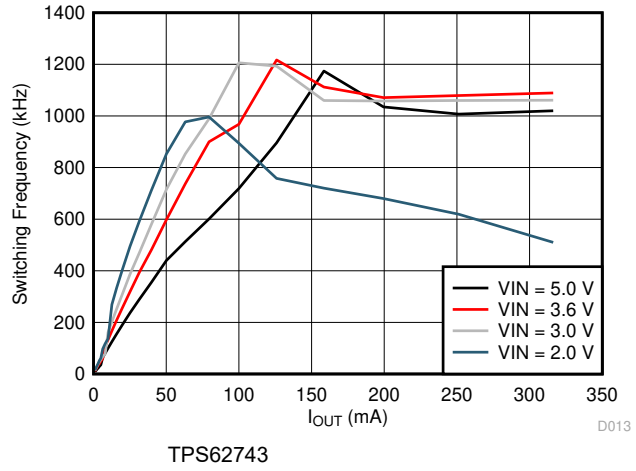



**図 9-12. Switching Frequency vs Load Current $V_{OUT}$ = 1.2 V**

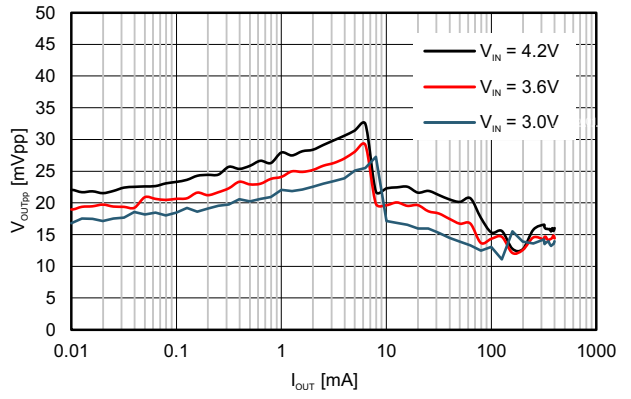



**図 9-13. Typical Output Ripple Voltage VOUT = 1.4V**

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### 9.2.3 Application Curves (continued)

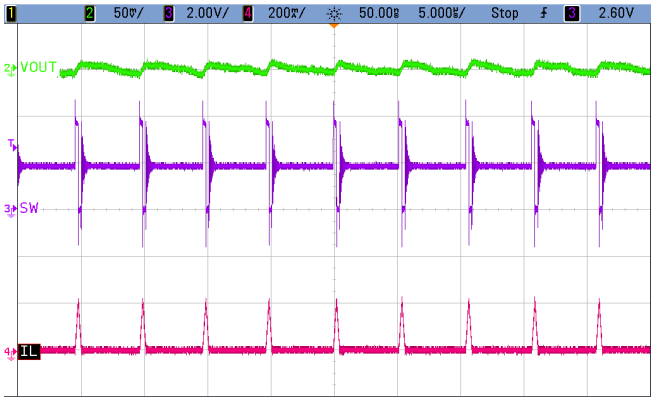



図 9-14. PFM (Power Save Mode) Mode Operation

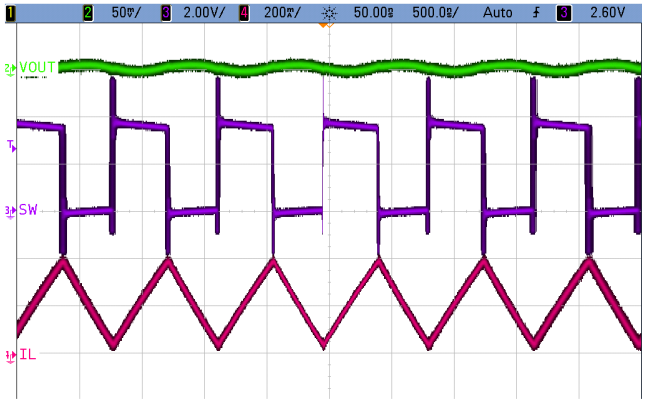



図 9-15. PWM Mode Operation




図 9-16. Startup Into 100 mA Electronic Load EN Delay + Soft-Start Delay

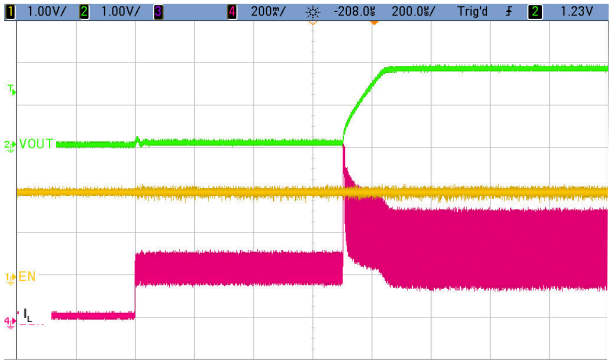



図 9-17. Startup Into 300 mA Electronic Load Soft-Start Delay

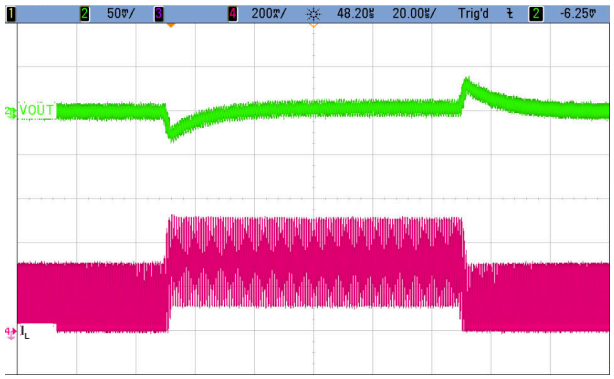



図 9-18. Load Transient Response; 100 mA to 290 mA

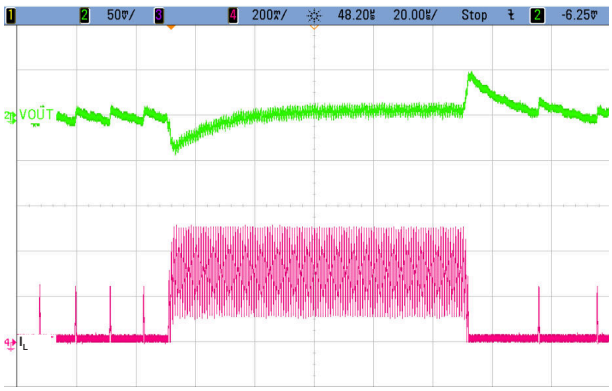



図 9-19. Load Transient Response; 5 mA to 290 mA


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### 9.2.3 Application Curves (continued)

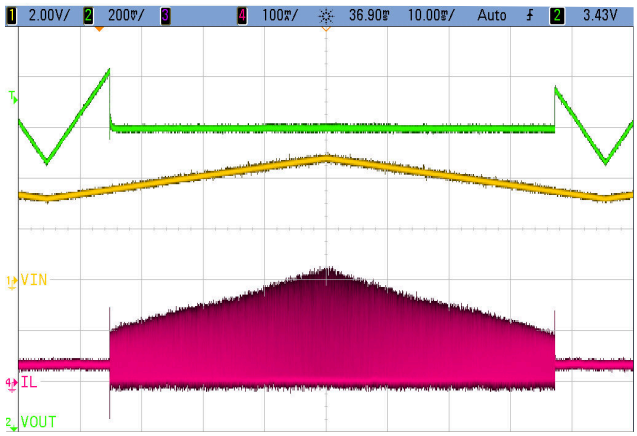



図 9-20. 100% Mode Entry and Leave Operation $I_{OUT}$ = 30 mA

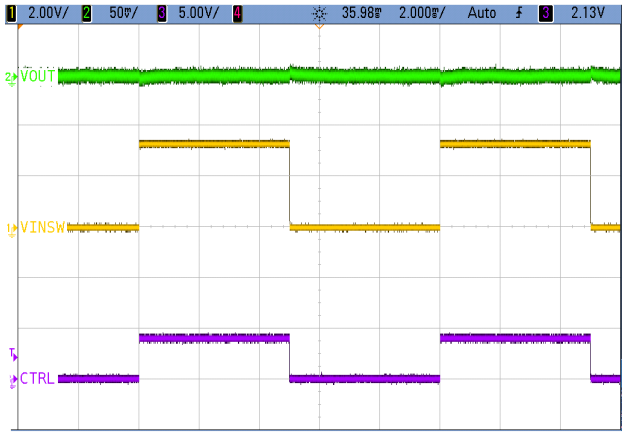



図 9-21. VINSW Operation and Control

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## 10 Power Supply Recommendations

The power supply must provide a current rating according to the supply voltage, output voltage and output current of the TPS62746.


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# 11 Layout

## 11.1 Layout Guidelines

- As for all switching power supplies, the layout is an important step in the design. Care must be taken in board layout to get the specified performance.
- It is critical to provide a low inductance, impedance ground path. Therefore, use wide and short traces for the main current paths.
- The input capacitor should be placed as close as possible to the IC pins VIN and GND. This is the most critical component placement.
- The $V_{OS}$ line is a sensitive high impedance line and should be connected to the output capacitor and routed away from noisy components and traces (e.g. SW line) or other noise sources.

## 11.2 Layout Example

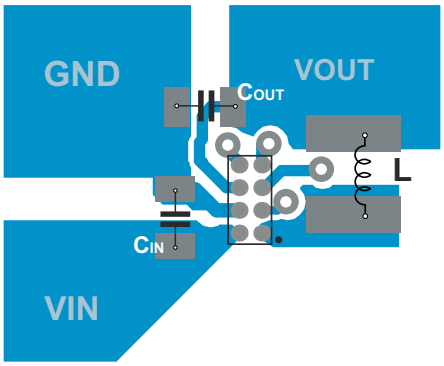



**図 11-1. Recommended PCB Layout**

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# 12 Device and Documentation Support

## 12.1 Device Support

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## 12.6 用語集

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。

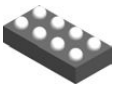
# 13 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.


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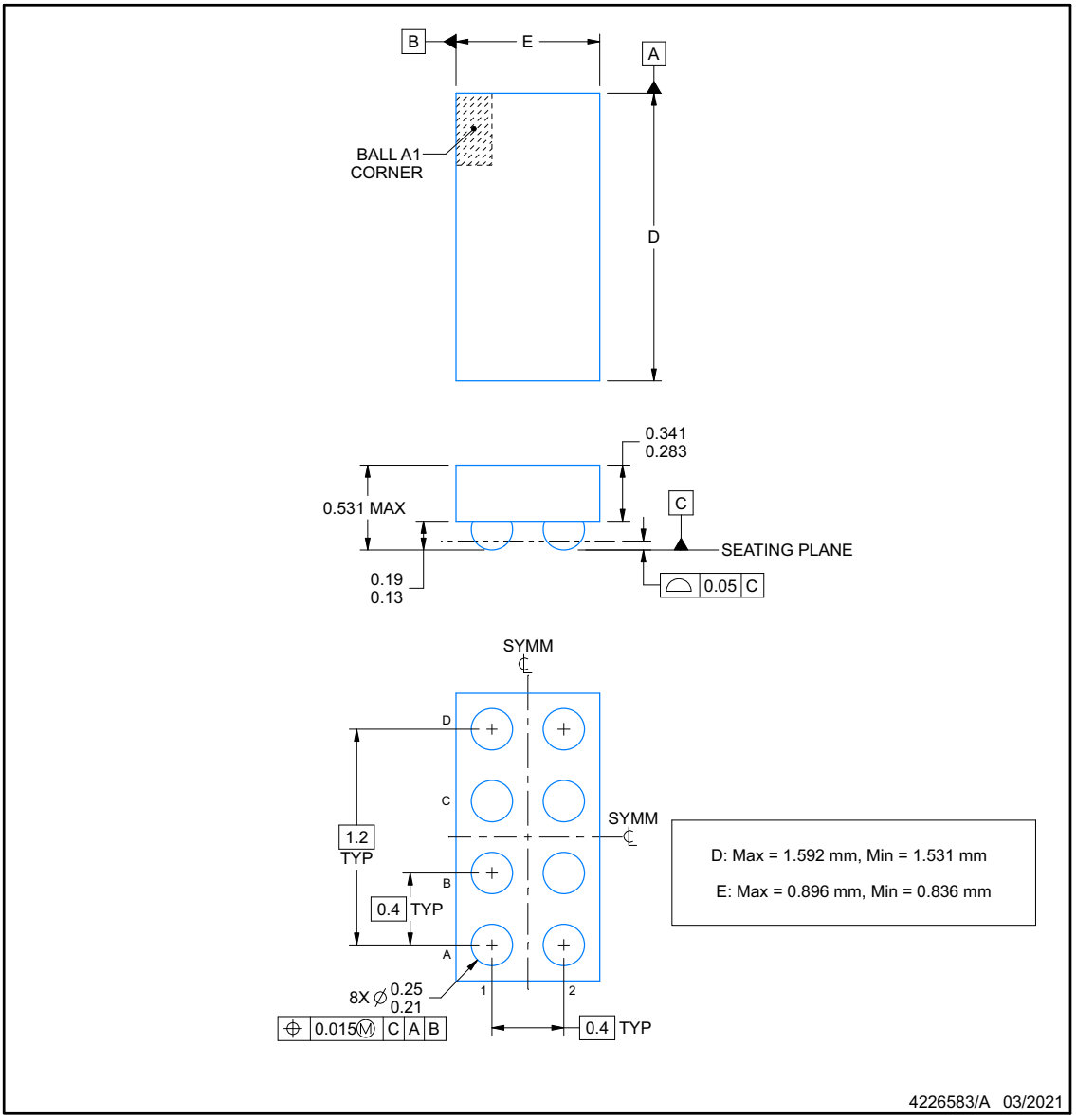
# PACKAGE OUTLINE

## YFP0008-C01



## DSBGA - 0.531 mm max height

DIE SIZE BALL GRID ARRAY




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.



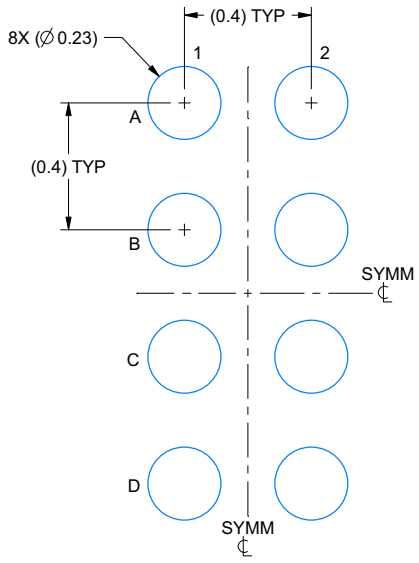
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## EXAMPLE BOARD LAYOUT

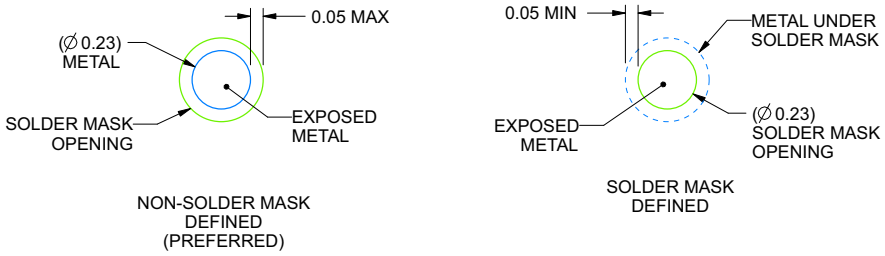
### YFP0008-C01

### DSBGA - 0.531 mm max height

DIE SIZE BALL GRID ARRAY




LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 50X




SOLDER MASK DETAILS
NOT TO SCALE

4226583/A 03/2021

NOTES: (continued)

3. Final dimensions may vary due to manufacturing tolerance considerations and also routing constraints.
   See Texas Instruments Literature No. SNVA009 (www.ti.com/lit/snva009).

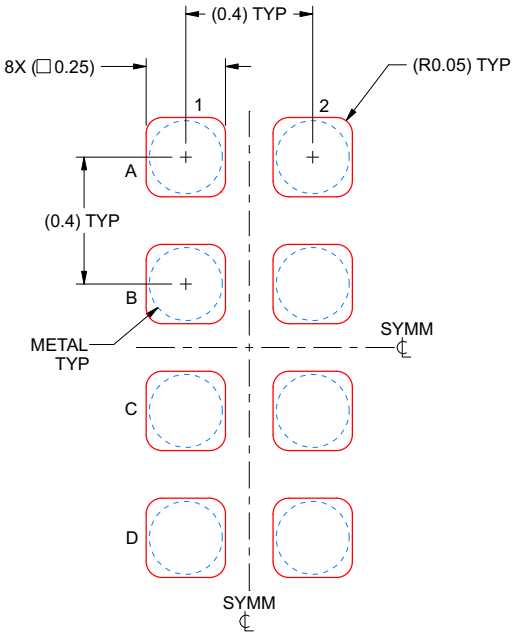

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# EXAMPLE STENCIL DESIGN

## YFP0008-C01

### DSBGA - 0.531 mm max height

DIE SIZE BALL GRID ARRAY




SOLDER PASTE EXAMPLE
BASED ON 0.1 mm THICK STENCIL
SCALE: 50X

4226583/A 03/2021

NOTES: (continued)

4. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release.



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## PACKAGING INFORMATION

| Orderable part number | Status (1) | Material type (2) | Package \| Pins | Package qty \| Carrier | RoHS (3) | Lead finish/ Ball material (4) | MSL rating/ Peak reflow (5) | Op temp (°C) | Part marking (6) |
|---|---|---|---|---|---|---|---|---|---|
| TPS62746YFPR | Active | Production | DSBGA (YFP) \| 8 | 3000 \| LARGE T&R | Yes | SNAGCU | Level-1-260C-UNLIM | -40 to 85 | TPS746 |
| TPS62746YFPR.B | Active | Production | DSBGA (YFP) \| 8 | 3000 \| LARGE T&R | Yes | SNAGCU | Level-1-260C-UNLIM | -40 to 85 | TPS746 |
| TPS62746YFPT | Active | Production | DSBGA (YFP) \| 8 | 250 \| SMALL T&R | Yes | SNAGCU | Level-1-260C-UNLIM | -40 to 85 | TPS746 |
| TPS62746YFPT.B | Active | Production | DSBGA (YFP) \| 8 | 250 \| SMALL T&R | Yes | SNAGCU | Level-1-260C-UNLIM | -40 to 85 | TPS746 |

(1) **Status:** For more details on status, see our product life cycle.

(2) **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

(3) **RoHS values:** Yes, No, RoHS Exempt. See the TI RoHS Statement for additional information and value definition.

(4) **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

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

(6) **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

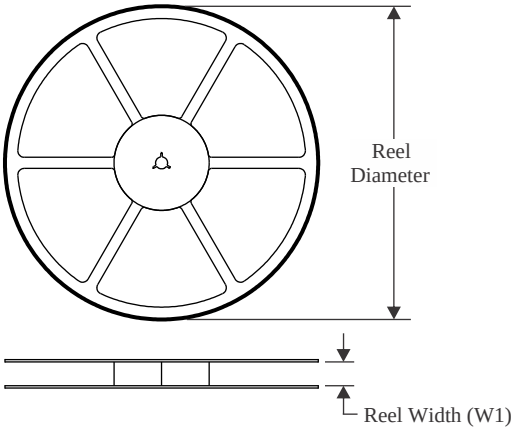
Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

**Important Information and Disclaimer:**The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

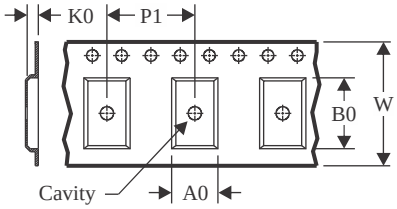
In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

## TAPE AND REEL INFORMATION

**REEL DIMENSIONS**

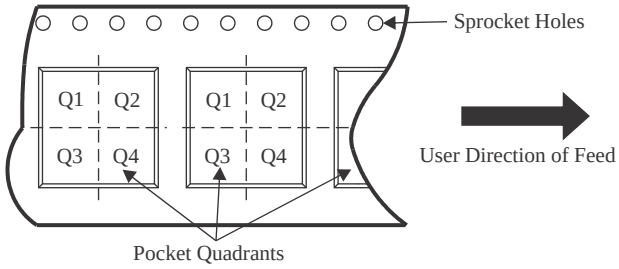



**TAPE DIMENSIONS**




| | |
|---|---|
| A0 | Dimension designed to accommodate the component width |
| B0 | Dimension designed to accommodate the component length |
| K0 | Dimension designed to accommodate the component thickness |
| W | Overall width of the carrier tape |
| P1 | Pitch between successive cavity centers |

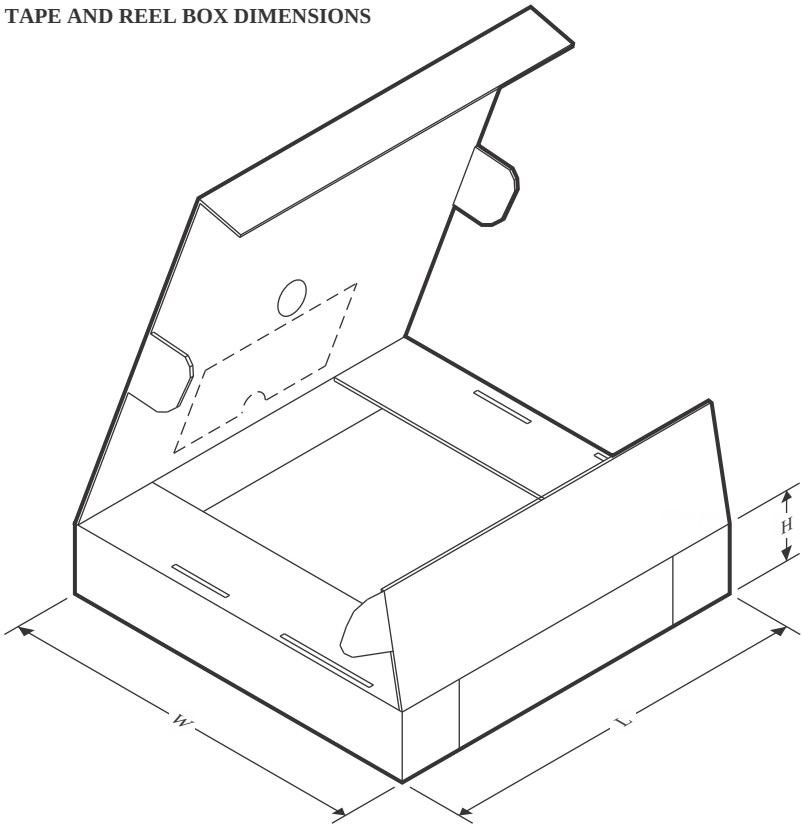
**QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE**




*All dimensions are nominal

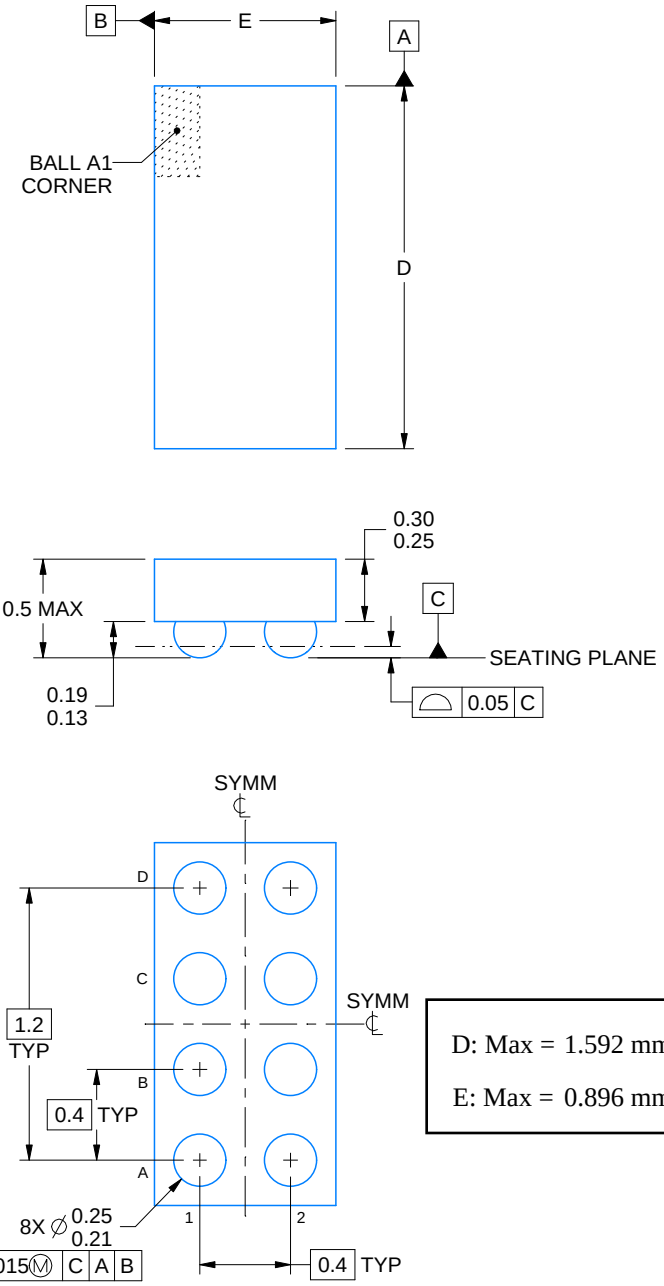
| Device | Package Type | Package Drawing | Pins | SPQ | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TPS62746YFPR | DSBGA | YFP | 8 | 3000 | 180.0 | 8.4 | 0.98 | 1.68 | 0.59 | 4.0 | 8.0 | Q1 |
| TPS62746YFPT | DSBGA | YFP | 8 | 250 | 180.0 | 8.4 | 0.98 | 1.68 | 0.59 | 4.0 | 8.0 | Q1 |

TAPE AND REEL BOX DIMENSIONS




*All dimensions are nominal

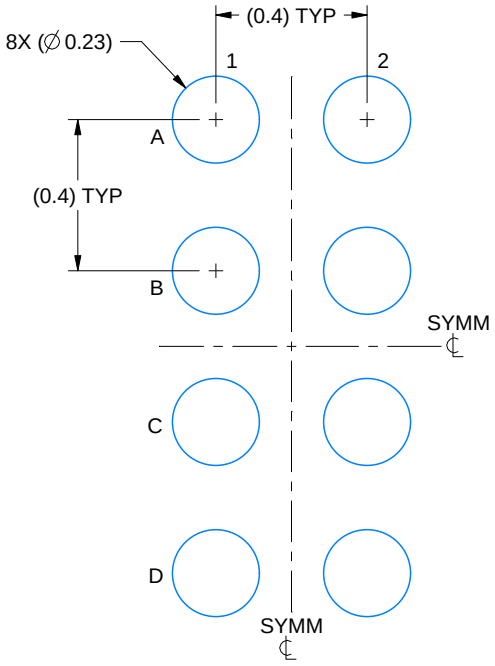
| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|---|---|---|---|---|---|---|---|
| TPS62746YFPR | DSBGA | YFP | 8 | 3000 | 182.0 | 182.0 | 20.0 |
| TPS62746YFPT | DSBGA | YFP | 8 | 250 | 182.0 | 182.0 | 20.0 |



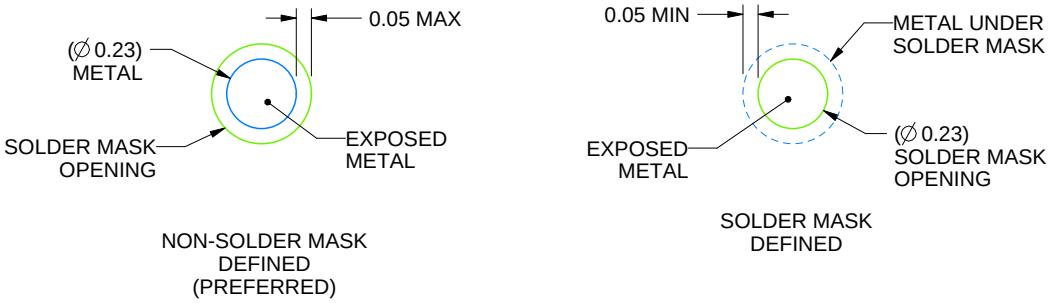

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NOTES:

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.




LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 50X

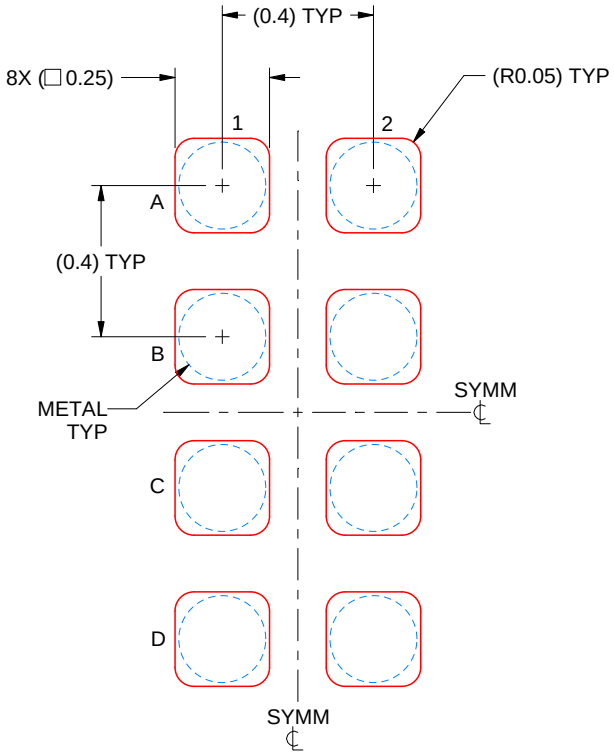



SOLDER MASK DETAILS
NOT TO SCALE

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NOTES: (continued)

3. Final dimensions may vary due to manufacturing tolerance considerations and also routing constraints.
   See Texas Instruments Literature No. SNVA009 (www.ti.com/lit/snva009).




SOLDER PASTE EXAMPLE
BASED ON 0.1 mm THICK STENCIL
SCALE: 50X

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NOTES: (continued)

4. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release.

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