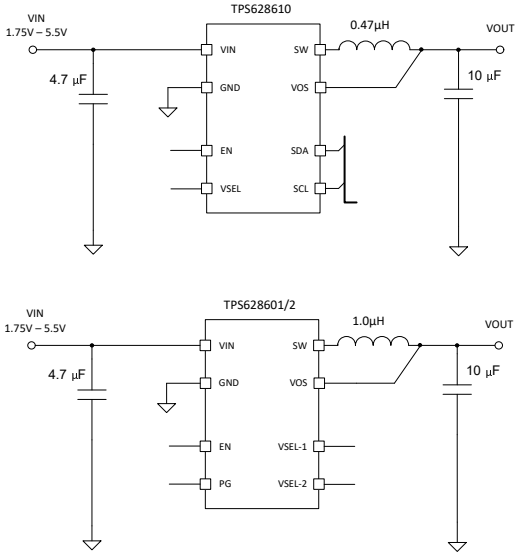
# TPS6286x 1.75V to 5.5V Input, 0.6/1A Synchronous Step-Down Converter With I²C/VSEL Interface

## 1 Features

- 2.3µA operating quiescent current
- Up to 4MHz switching frequency
- 1% output voltage accuracy
- DVS output from
  - 0.4V to 1.9875V (12.5mV steps)
- I²C user interface to adjust
  - Output voltage presets
  - Ramp speed
- VSEL pin to toggle output voltage during operation
- Power-good indication
- Supports < 6mm² design size
- Supports < 0.6mm design height
- Tiny, 8-pin, 0.35mm pitch WCSP package
- Optimized pinout to support 0201 components

## 2 Applications

- Wearable electronics
- Portable electronics
- Mobile phones
- Medical sensor patches and patient monitors




**Typical Application**

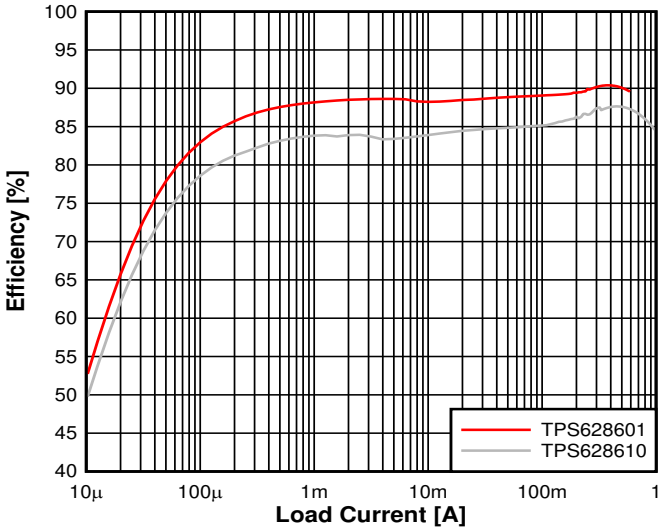
## 3 Description

The TPS6286x devices are high-frequency, synchronous step-down converters with I2C- and VSEL-Interface. The devices provide an efficient, flexible, and high-power density point-of-load DC/DC design. At medium to heavy loads, the converter operates in PWM mode and automatically enters Power Save Mode operation at light load to maintain high efficiency over the entire load current range. The device can also be forced in PWM mode operation for the smallest output voltage ripple. Together, with the DCS-Control architecture, excellent load transient performance and tight output voltage accuracy are achieved. With the I²C interface and a dedicated VSEL pin, the output voltage is quickly adjusted to adapt the power consumption of the load to the ever-changing performance needs of the application. The device family is available with two VSEL pins and four factory preset voltages to allow usage without I²C interface.

**Device Information**

| PART NUMBER(3) | CURRENT | PACKAGE(1) | PACKAGE SIZE(2) |
|---|---|---|---|
| TPS62861 | 1A | YCH (DSBGA, 8) | 1.40mm × 0.70mm |
| TPS62860 | 0.6A | | |

(1) For more information, see Section 12.
(2) The package size (length × width) is a nominal value and includes pins, where applicable.
(3) See the *Device Comparison Table*.




**Efficiency vs $I_{OUT}$ at $1.1V_{OUT}$, $3.8V_{IN}$**

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## 4 Device Comparison Table

| ORDERABLE NUMBER | OUTPUT CURRENT (A) | DEFAULT $V_{OUT}$ SETTING (V) | DEFAULT OPERATION | I2C ADDRESS | SWITCHING FREQUENCY $f_{SW}$(MHz) | USER INTERFACE |
|---|---|---|---|---|---|---|
| TPS628600YCH | 0.6 | 0.6, 1.1 | Normal (PWM, PFM) operation(1) | 0x40 | 1.5 | EN, I2C, VSEL |
| TPS628601YCH | 0.6 | 0.6, 0.7, 0.8, 1.0 | Normal (PWM, PFM) operation | 0x40 | 1.5 | 2× VSEL, EN, PG |
| TPS628603YCH | 0.6 | 1.05, 0.65 | Normal (PWM, PFM) operation | 0x40 | 1.5 | EN, I2C, VSEL |
| TPS628604YCH | 0.6 | 0.85, 1.1 | Normal (PWM, PFM) operation | 0x40 | 1.5 | EN, I2C, VSEL |
| TPS628610YCH | 1 | 0.6 , 1.1 | Normal (PWM, PFM) operation | 0x40 | 4 | EN, I2C, VSEL |
| TPS628605YCH | 0.6 | 1.8, 1.8 | VSEL = LOW (normal (PWM, PFM) operation), VSEL = HIGH (FPWM operation)(2) | 0x41 | 1.5 | EN, I2C, VSEL |
| TPS628606YCH | 0.6 | 1.0125, 1.0125 | VSEL = LOW (normal (PWM, PFM) operation), VSEL = HIGH (FPWM operation) | 0x40 | 1.5 | EN, I2C, VSEL |

(1) Normal operation: default value of operation mode[7] of Vout Register 2 = 0 (Table 8-3).
(2) FPWM operation: default value of operation mode[7] of Vout Register 2 = 1 (Table 8-3).

# 5 Pin Configuration and Functions

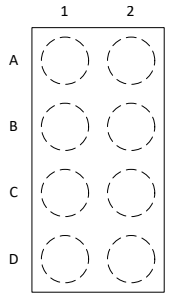



**Figure 5-1. 8-Pin DSBGA YCH Package (Top View)**

**Table 5-1. Pin Functions, TPS628610, TPS628600, TPS628603, TPS628604, TPS628605, and TPS628606**

| PIN | | TYPE | DESCRIPTION |
|---|---|---|---|
| NAME | NO. | | |
| GND | D2 | PWR | GND supply pin. Connect this pin close to the GND terminal of the input and output capacitor. |
| VOS | D1 | IN | Output voltage sense pin for the internal feedback divider network and regulation loop. This pin also discharges $V_{OUT}$ by an internal MOSFET when the converter is disabled. Connect this pin directly to the output capacitor with a short trace. |
| VIN | C2 | PWR | $V_{IN}$ power supply pin. Connect the input capacitor close to this pin for best noise and voltage spike suppression. A ceramic capacitor is required. |
| SW | C1 | PWR | The switch pin is connected to the internal MOSFET switches. Connect the inductor to this terminal. |
| VSEL | B2 | IN | Voltage selection pin. Can be toggled during operation. LOW = 0.6 V (TPS628600, TPS628610), 1.05 V (TPS628603), HIGH = 1.1 V (TPS628600, TPS628610), 0.65 V (TPS628603) |
| EN | B1 | IN | A high level enables the devices and a low level turns the device off. The pin features an internal pulldown resistor, which is disabled after the device has started up. |
| SDA | A2 | IN | $I^2C$ serial data pin. Do not leave floating. |
| SCL | A1 | IN | $I^2C$ serial clock pin. Do not leave floating. |

**Table 5-2. Pin Functions, TPS628601**

| PIN | | TYPE | DESCRIPTION |
|---|---|---|---|
| NAME | NO. | | |
| GND | D2 | PWR | GND supply pin. Connect this pin close to the GND terminal of the input and output capacitor. |
| VOS | D1 | IN | Output voltage sense pin for the internal feedback divider network and regulation loop. This pin also discharges VOUT by an internal MOSFET when the converter is disabled. Connect this pin directly to the output capacitor with a short trace. |
| VIN | C2 | PWR | VIN power supply pin. Connect the input capacitor close to this pin for best noise and voltage spike suppression. A ceramic capacitor is required. |
| SW | C1 | PWR | The switch pin is connected to the internal MOSFET switches. Connect the inductor to this terminal. |
| PG | B2 | OUT | Open-drain power-good output |
| EN | B1 | IN | A high level enables the devices and a low level turns the device off. The pin features an internal pulldown resistor, which is disabled after the device has started up. |
| VSEL-1 | A2 | IN | Voltage Selection Pin. Can be toggled during operation. |
| VSEL-2 | A1 | IN | Voltage Selection Pin. Can be toggled during operation. |

# 6 Specifications

## 6.1 Absolute Maximum Ratings

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

| | | MIN | MAX | UNIT |
|---|---|---|---|---|
| Pin voltage | VIN | –0.3 | 6 | V |
| Pin voltage | SW, DC | –0.3 | $V_{IN}$ +0.3V | V |
| Pin voltage | SW, transient < 10 ns, while switching | –2.5 | 9 | V |
| Pin voltage | EN, VSEL, SDA, SCL, PG | –0.3 | 6 | V |
| Pin voltage | VOS | –0.3 | 5 | V |
| $T_J$ | Operating junction temperature | –40 | 150 | °C |
| $T_{stg}$ | Storage temperature | –55 | 150 | °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 |
|---|---|---|---|---|
| $V_{(ESD)}$ | Electrostatic discharge | Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001 (1) | ±2000 | V |
| | | Charged-device model (CDM), per ANSI/ESDA/JEDEC JS-002 (2) | ±500 | |

(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

Over operating junction temperature range (unless otherwise noted)

| | | | MIN | NOM | MAX | UNIT |
|---|---|---|---|---|---|---|
| $V_{IN}$ | Input supply voltage range | | 1.75 | | 5.5 | V |
| $V_{OUT}$ | Output voltage range | | 0.4 | | 1.9875 | V |
| | Pin voltage | SW | 0 | | 5.5 | V |
| | Pin voltage | EN, SDA, SCL, VSEL, PG | 0 | | 5.5 | V |
| $I_{OUT}$ | Output current range | TPS628610, $V_{IN}$ > 2.3V | | | 1 | A |
| $I_{OUT}$ | Output current range | TPS628610, $V_{IN}$ <= 2.3V | | | 0.7 | A |
| $I_{OUT}$ | Output current range | TPS628601 | | | 0.6 | A |
| $I_{PG}$ | Power Good input current capability | | | | 1 | mA |
| $T_J$ | Operating junction temperature | | -40 | | 125 | °C |
| $C_{IN}$ | Effective Input Capacitance | | 2 | 4.7 | | µF |
| L | Effective Inductance | TPS628610 | 0.33 | 0.47 | 0.82 | µH |
| COUT | Effective Output Capacitance | | 2 | | 26 | µF |
| L | Effective Inductance | TPS628601 | 0.7 | 1.0 | 1.2 | µH |
| COUT | Effective Output Capacitance | | 3 | | 26 | µF |

## 6.4 Thermal Information

| THERMAL METRIC(1) | | DEVICE YCH (DSBGA) 8 PINs | UNIT |
|---|---|---|---|
| $R_{\theta JA}$ | Junction-to-ambient thermal resistance | 121.9 | °C/W |
| $R_{\theta JC(top)}$ | Junction-to-case (top) thermal resistance | 1.1 | °C/W |
| $R_{\theta JB}$ | Junction-to-board thermal resistance | 33.7 | °C/W |
| $\psi_{JT}$ | Junction-to-top characterization parameter | 0.7 | °C/W |

## 6.4 Thermal Information (continued)

| THERMAL METRIC[1] | | DEVICE | UNIT |
|---|---|---|---|
| | | YCH (DSBGA) | |
| | | 8 PINs | |
| $\psi_{JB}$ | Junction-to-board characterization parameter | 33.5 | °C/W |

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

## 6.5 Electrical Characteristics

$T_J$ = –40°C to +125°C, $V_{IN}$ = 3.6 V. Typical values are at $T_J$ = 25°C (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| **SUPPLY** | | | | | | |
| $I_{Q(VIN)}$ | VIN quiescent current | EN = VIN, IOUT = 0µA, VOUT = 1.2 V device not switching, TJ = -40°C to +85°C | | 2.3 | 4 | µA |
| | | EN = VIN, IOUT = 0µA, VOUT = 1.2 V, device switching | | 2.5 | | µA |
| $I_{SD(VIN)}$ | VIN shutdown supply current | EN = GND, shutdown current into VIN VSEL/MODE = GND, TJ = -40°C to +85°C | | 120 | 250 | nA |
| **UVLO** | | | | | | |
| $V_{UVLO(R)}$ | VIN UVLO rising threshold | $V_{IN}$ rising | | 1.65 | 1.75 | V |
| $V_{UVLO(F)}$ | VIN UVLO falling threshold | $V_{IN}$ falling | | 1.56 | 1.7 | V |
| $V_{UVLO(H)}$ | VIN UVLO hysteresis | | | 100 | | mV |
| **LOGIC PINs** | | | | | | |
| $V_{IH}$ | High-level input voltage threshold | | 0.8 | | | V |
| $V_{IL}$ | Low-level input voltage threshold | | | | 0.4 | V |
| $I_{LKG}$ | Input leakage current into SDA, SCL, VSEL | Pin connected to VIN | | 10 | 25 | nA |
| | EN internal pull-down resistance | EN pin to GND | | 0.5 | | MΩ |
| $I_{LKG}$ | Input Leakage into EN | Pin connected to VIN | | 10 | 25 | nA |
| **VOUT VOLTAGE** | | | | | | |
| $V_{OUT}$ | Output Voltage Accuracy | PWM Mode, no load, $T_J$ = 25°C to 85°C | -1 | | +1 | % |
| $V_{OUT}$ | Output Voltage Accuracy | PWM Mode, no load, $T_J$ = -40°C to 125°C | -2 | | +1.7 | % |
| $I_{VOS(LKG)}$ | VOS input leakage current | EN = VIN, VOUT = 1.2 V (internal 12MΩ resistor divider), TJ = -40°C to +85°C | | 100 | 400 | nA |
| **SWITCHING FREQUENCY** | | | | | | |
| $f_{SW(FCCM)}$ | Switching frequency, TPS62861x | VIN = 3.6V, VOUT =1.2V, PWM operation | | 4 | | MHz |
| $f_{SW(FCCM)}$ | Switching frequency, TPS62860x | VIN = 3.6V, VOUT =1.2V, PWM operation | | 1.5 | | MHz |
| **STARTUP** | | | | | | |
| | Internal fixed soft-start time | from VOUT = 0V to 95% of VOUT nominal | | 0.125 | 0.2 | ms |
| | EN HIGH to start of switching delay | | | 500 | 1000 | µs |
| **POWER STAGE** | | | | | | |
| $R_{DSON(HS)}$ | High-side MOSFET on-resistance | IOUT = 500 mA | | 120 | 170 | mΩ |
| $R_{DSON(LS)}$ | Low-side MOSFET on-resistance | IOUT = 500 mA | | 80 | 115 | mΩ |
| **OVERCURRENT PROTECTION** | | | | | | |
| $I_{HS(OC)}$ | High-side peak current limit | TPS628610 | 1.3 | 1.45 | 1.55 | A |
| $I_{LS(OC)}$ | Low-side valley current limit | TPS628610 | 1.2 | 1.35 | 1.45 | A |
| $I_{HS(OC)}$ | High-side peak current limit | TPS628601 | 0.95 | 1.1 | 1.2 | A |
| $I_{LS(OC)}$ | Low-side valley current limit | TPS628601 | 0.85 | 1.0 | 1.1 | A |
| $I_{LS(NOC)}$ | Low-side negative current limit | Sinking current limit on LS FET | | 0.8 | | A |
| **POWER GOOD** | | | | | | |
| $V_{PGTH}$ | Power Good threshold | PGOOD low, VOS falling | | 93% | | |
| $V_{PGTH}$ | Power Good threshold | PGOOD high, VOS rising | | 96% | | |
| $t_{PG:DLY}$ | Power good deglitch delay | PG rising edge | | 16 | | µs |

## 6.5 Electrical Characteristics (continued)

$T_J$ = –40°C to +125°C, $V_{IN}$ = 3.6 V. Typical values are at $T_J$ = 25°C (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| $I_{PG;LKG}$ | Input leakage current into PG-pin | $V_{PG}$ = 5.0V | | 10 | 100 | nA |
| | PG-pin output low-level voltage | $I_{PG}$ = 1mA | | | 400 | mV |
| **OUTPUT DISCHARGE** | | | | | | |
| | Output discharge resistor on VOS pin | EN = GND, IVOS = –10 mA into VOS pin<br>TJ = -40°C to +85°C | | 7 | 11 | Ω |
| **THERMAL SHUTDOWN** | | | | | | |
| $T_{J(SD)}$ | Thermal shutdown threshold (1) | Temperature rising, PWM Mode | | 160 | | °C |
| $T_{J(HYS)}$ | Thermal shutdown hysteresis (1) | | | 20 | | °C |

(1) Specified by design. Not production tested.

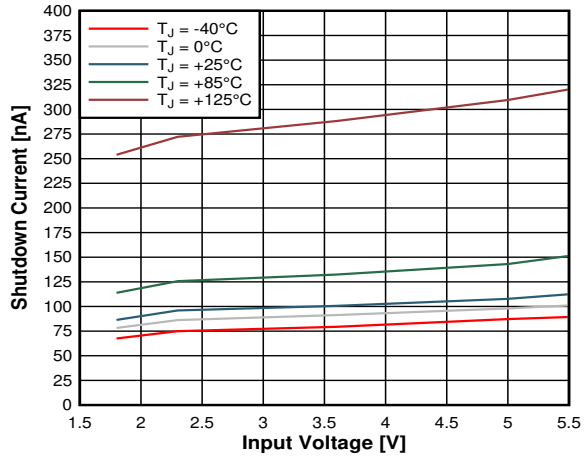
## 6.6 I²C Interface Timing Characteristics

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| $f_{SCL}$ | SCL Clock Frequency | Standard mode | | | 100 | kHz |
| | | Fast mode | | | 400 | kHz |
| | | Fast mode plus | | | 1 | MHz |
| $t_{BUF}$ | Bus Free Time Between a STOP and START Condition | Standard mode | 4.7 | | | µs |
| | | Fast mode | 1.3 | | | µs |
| | | Fast mode plus | 0.5 | | | µs |
| $t_{HD}$, $t_{STA}$ | Hold Time (Repeated) START condition | Standard mode | 4 | | | µs |
| | | Fast mode | 600 | | | ns |
| | | Fast mode plus | 260 | | | ns |
| $t_{LOW}$ | LOW Period of the SCL Clock | Standard mode | 4.7 | | | µs |
| | | Fast mode | 1.3 | | | µs |
| | | Fast mode plus | 0.5 | | | µs |
| $t_{HIGH}$ | HIGH Period of the SCL Clock | Standard mode | 4 | | | µs |
| | | Fast mode | 600 | | | ns |
| | | Fast mode plus | 260 | | | ns |
| $t_{SU}$, $t_{STA}$ | Setup Time for a Repeated START Condition | Standard mode | 4.7 | | | µs |
| | | Fast mode | 600 | | | ns |
| | | Fast mode plus | 260 | | | ns |
| $t_{SU}$, $t_{DAT}$ | Data Setup Time | Standard mode | 250 | | | ns |
| | | Fast mode | 100 | | | ns |
| | | Fast mode plus | 50 | | | ns |
| $t_{HD}$, $t_{DAT}$ | Data Hold Time | Standard mode | 0 | | 3.45 | µs |
| | | Fast mode | 0 | | 0.9 | µs |
| | | Fast mode plus | 0 | | | µs |
| $t_{RCL}$ | Rise Time of SCL Signal | Standard mode | | | 1000 | ns |
| | | Fast mode | 20+0.1CB | | 300 | ns |
| | | Fast mode plus | | | 120 | ns |
| $t_{RCL1}$ | Rise Time of SCL Signal After a Repeated START Condition and After an Acknowledge BIT | Standard mode | 20+0.1CB | | 1000 | ns |
| | | Fast mode | 20+0.1CB | | 300 | ns |
| | | Fast mode plus | | | 120 | ns |

## 6.6 I²C Interface Timing Characteristics (continued)

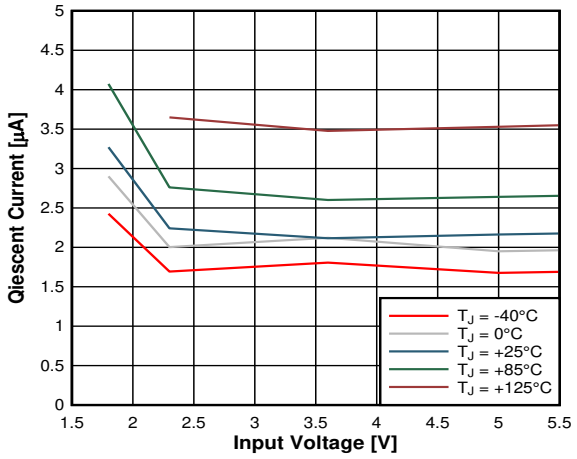
| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| $t_{FCL}$ | Fall Time of SCL Signal | Standard mode | 20+0.1CB | | 300 | ns |
| | | Fast mode | | | 300 | ns |
| | | Fast mode plus | | | 120 | ns |
| $t_{RDA}$ | Rise Time of SDA Signal | Standard mode | | | 1000 | ns |
| | | Fast mode | 20+0.1CB | | 300 | ns |
| | | Fast mode plus | | | 120 | ns |
| $t_{FDA}$ | Fall Time of SDA Signal | Standard mode | | | 300 | ns |
| | | Fast mode | 20+0.1CB | | 300 | ns |
| | | Fast mode plus | | | 120 | ns |
| $t_{SU}$, $t_{STO}$ | Setup Time of STOP Condition | Standard mode | 4 | | | µs |
| | | Fast mode | 600 | | | ns |
| | | Fast mode plus | 260 | | | ns |
| CB | Capacitive Load for SDA and SCL | Standard mode | | | 400 | pF |
| | | Fast mode | | | 400 | pF |
| | | Fast mode plus | | | 550 | pF |

## 6.7 Typical Characteristics




EN = GND

**Figure 6-1. Shutdown Current $I_{SD}$**




EN = VIN Device not switching

**Figure 6-2. Quiescent Current $I_Q$**

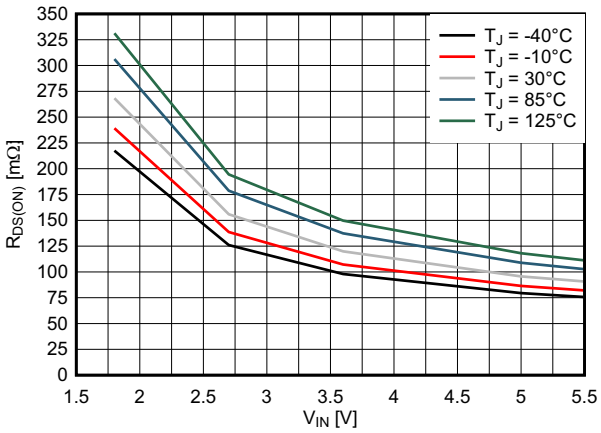



**Figure 6-3. High-side Switch Drain Source Resistance $R_{DS(ON)}$**

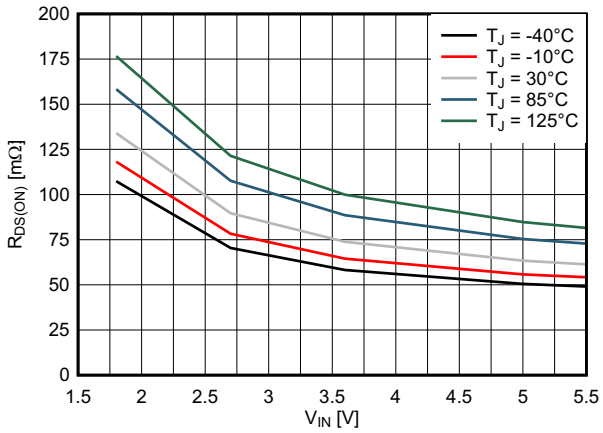


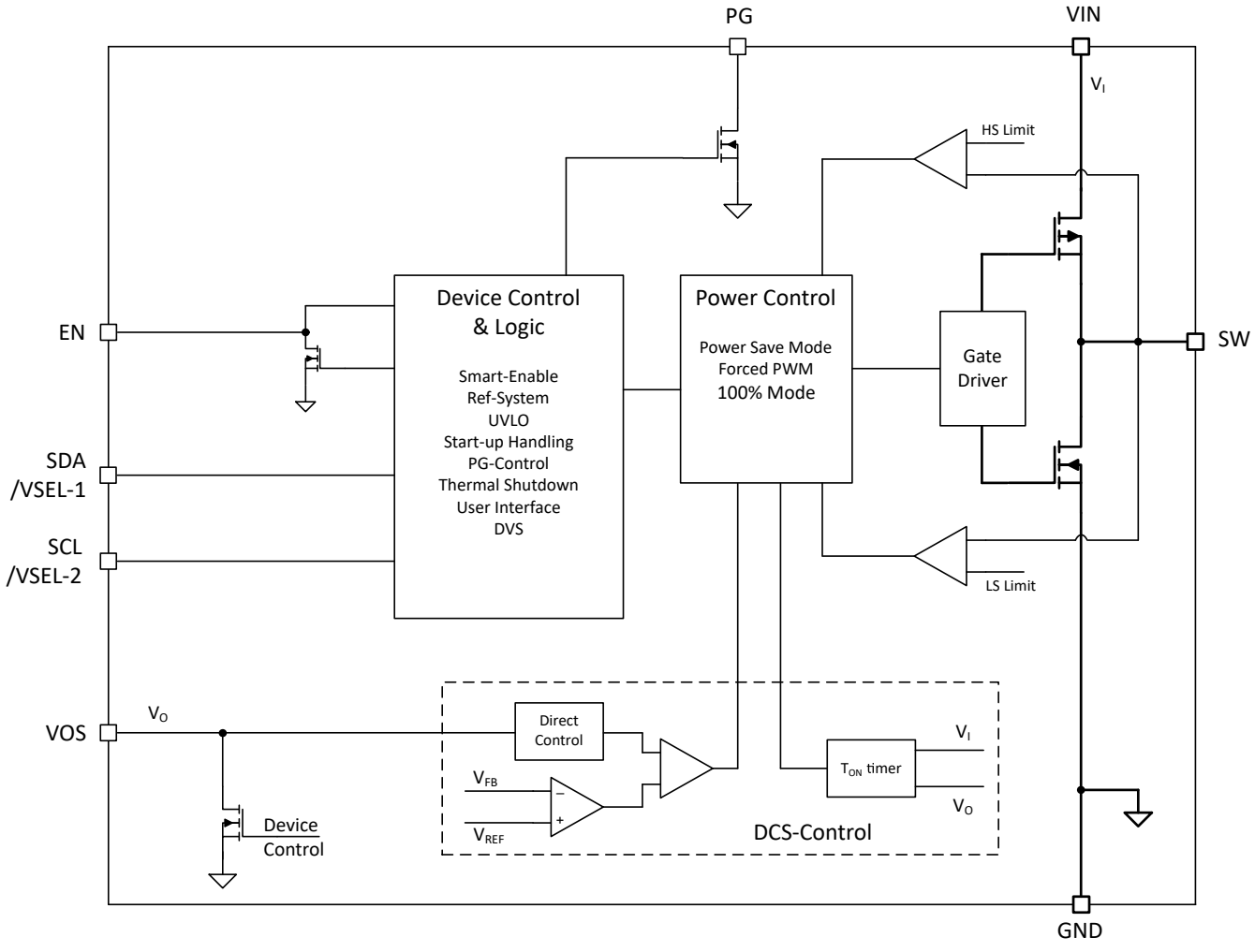

**Figure 6-4. Low-side Switch Drain Source Resistance $R_{DS(ON)}$**

# 7 Detailed Description

## 7.1 Overview

The TPS6286x is a high-frequency synchronous step-down converter with ultra-low quiescent current consumption and flexible output voltage by I²C or VSEL interface. Using TI's DCS-Control topology, the device extends the high efficiency operation area down to microamperes of load current during Power Save Mode Operation. 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. 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.

## 7.2 Functional Block Diagram



## 7.3 Feature Description

### 7.3.1 Soft Start

After the device has been enabled with EN high, it initializes and powers up the internal circuits. This occurs during the regulator start-up delay time, $t_{Delay}$. After $t_{Delay}$ expires, the internal soft-start circuitry ramps up the output voltage within the soft-start time, $t_{Ramp}$. See Figure 7-1.

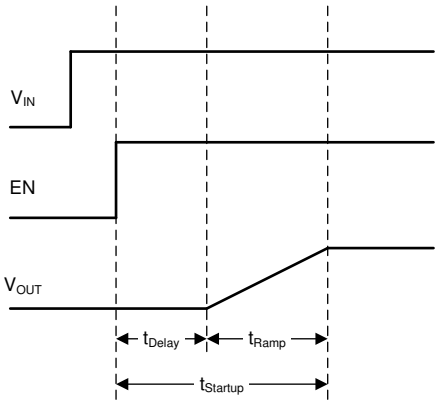



**Figure 7-1. Start-up Sequence**

### 7.3.2 Output Voltage Selection (VSEL) for TPS62860x

The optional VSEL Interface allows setting the output voltage by a 2-pin HIGH/LOW setting. Using and applying a digital pattern to the "VSEL-1" and "VSEL-2" pins sets the output voltage according to Table 7-1.

**Table 7-1. Target Output Voltage Setting by VSEL Interface**

| VSEL-2 | VSEL-1 | TPS628601 | TPS628602 | OPERATION MODE |
|---|---|---|---|---|
| 0 | 0 | 0.6 V | 1.05 V | PFM Mode |
| 0 | 1 | 0.7 V | 0.9 V | PFM Mode |
| 1 | 0 | 0.8 V | 0.875 V | PFM Mode |
| 1 | 1 | 1.0 V | 0.625 V | PFM Mode |

### 7.3.3 Output Voltage Selection (VSEL and $I^2C$)

The TPS6286x has two options to select the output voltage.

The voltage on the VSEL pin can change the output voltage. Putting this pin HIGH selects the output voltage according to $V_{OUT}$ register 2. Putting this pin LOW selects the voltage according to $V_{OUT}$ Register 1. The pin can be toggled during operation.

The pin can also be selected by the value in the $V_{OUT}$ register that is chosen by VSEL at the moment. The voltage changes right after the $I^2C$ command is received.

### 7.3.4 Undervoltage Lockout (UVLO)

To avoid misoperation of the device at low input voltages, an undervoltage lockout (UVLO) comparator monitors the supply voltage. The UVLO comparator shuts down the device at an input voltage of 1.7 V (maximum) with falling VIN. The device starts at an input voltage of 1.8 V (maximum) rising VIN. After the device re-enters operation out of an undervoltage lockout condition, the device behaves like being enabled.

### 7.3.5 Power Good (PG)

The built-in power-good (PG) signal indicates that the output voltage has reached the target and the device is ready. The PG signal can be used for start-up sequencing of multiple rails or to indicate any overload behavior on the output. The PG pin is an open-drain output that requires a pullup resistor to any voltage up to the recommended input voltage level. PG is low when the device is turned off due to EN or thermal shutdown. VIN

must remain present for the PG pin to stay LOW. When applying VIN the first time, PG stays HIGH until the first enabling of the device.

If the power-good output is not used, TI recommends to tie to GND or leave open.

**Table 7-2. Power Good Indicator Functional Table**

| LOGIC SIGNALS | | | | | PG STATUS |
|---|---|---|---|---|---|
| $V_I$ | EN-PIN | THERMAL SHUTDOWN | $V_{OUT}$ | DVS TRANSITION ACTIVE | |
| $V_I$ > UVLO | HIGH | NO | $V_{OUT}$ on target | NO | **High Impedance** |
| | | | | YES | **LOW** |
| | | | $V_{OUT}$ < target | x | **LOW** |
| | | YES | x | x | **LOW** |
| | LOW | x | x | x | **LOW** |
| $V_I$ < UVLO | x | x | x | x | **Undefined** |

The PG indicator triggers immediately (after internal comparator delay) when $V_O$ crosses the lower $V_{PGTH}$ to indicate that the voltage has left the target setting. It features a delay after crossing the upper $V_{PGTH}$ when going high to make sure $V_O$ has reached the target again. Figure 7-2 sketches the behavior.

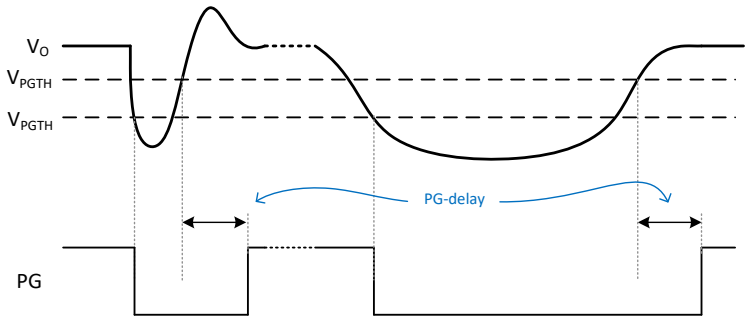



**Figure 7-2. Power Good Transient and De-glitch Behavior**

The PG Indicator is by default pulled low during DVS transition of the output voltage without any blanking or delay time. Figure 7-2 shows an example of this behavior. After $V_O$ has reached the new target, the PG is again active as shown in Figure 7-2.

### *7.3.6 Switch Current Limit and Short Circuit Protection*

The TPS6286x integrates a current limit on the high-side and low-side MOSFETs to protect the converter against overload or short-circuit conditions. The current in the switches is monitored cycle by cycle. If the high-side MOSFET current limit, $I_{LIMF}$, trips, the high-side MOSFET is turned off and the low-side MOSFET is turned on to ramp down the inductor current. After the inductor current through the low-side switch decreases below the low-side MOSFET current limit, $I_{LIMF}$, the low-side MOSFET is turned off and the high-side MOSFET turns on again.

### *7.3.7 Thermal Shutdown*

The junction temperature ($T_J$) of the device is monitored by an internal temperature sensor. If $T_J$ exceeds the thermal shutdown temperature TSD of 160°C (typ), the device enters thermal shutdown. Both the high-side and low-side power FETs are turned off. When $T_J$ decreases below the hysteresis amount of typically 20°C, the converter resumes operation, beginning with a soft start to the originally set VOUT. The thermal shutdown is not active in Power Save Mode.

### *7.3.8 Output Voltage Discharge*

The purpose of the output discharge function is to make sure a defined down-ramp of the output voltage when the device is disabled and to keep the output voltage close to 0 V. The output discharge feature is only active

after the device has been enabled at least once since the supply voltage was applied. The output discharge function is not active if the device is disabled and the supply voltage is applied the first time. The internal discharge resistor is connected to the VOS pin. The discharge function is enabled as soon as the device is disabled. The minimum supply voltage required to keep the discharge function active is $V_I > V_{TH\_UVLO-}$.

## 7.4 Device Functional Modes

### *7.4.1 Smart Enable and Shutdown (EN)*

An internal 500-kΩ resistor pulls the EN pin to GND and avoids the pin to be floating. This prevents an uncontrolled start-up of the device in case the EN pin cannot be driven to low level safely. With EN low, the device is in shutdown mode. The device is turned on with EN set to a high level. The pulldown control circuit disconnects the pulldown resistor on the EN pin after the internal control logic and the reference have been powered up. With EN set to a low level, the device enters shutdown mode and the pulldown resistor is activated again.

### *7.4.2 Forced PWM Operation*

Through $I^2C$, set the device in forced PWM (FPWM) mode by the CONTROL register. The device switches continuously, even with a light load. This reduces the output voltage ripple and allows simple filtering of the switching frequency for noise-sensitive applications. Efficiency at light load is lower in FPWM mode.

### *7.4.3 Forced PWM Mode During Output Voltage Change*

In normal operation, the device does not force PWM operation during VOUT change after VSEL toggle or $I^2C$ command. For ramping down, this mode provides the remaining energy, stored in the output capacitor to the load of the DC/DC and save battery charge. See Figure 9-14.

Through $I^2C$, the device can be set to forced PWM (FPWM) switching during output voltage change. This allows a controlled ramp of $V_{OUT}$ up and especially down, regardless of the load condition. See Figure 9-15.

This feature follows the internal $I^2C$ ramp and is only recommended for the setting 1 mV/µs and 0.1 mV/µs. During the faster slopes (10 mV/µs and 5 mV/µs), the mode is likely to be left before the voltage reached the new target value.

### *7.4.4 Power Save Mode*

As the load current decreases, the device enters Power Save Mode (PSM) operation. PSM occurs when the inductor current becomes discontinuous, which is when the inductor current reaches 0 A during a switching cycle. In power save mode, the output voltage rises slightly above the nominal output voltage. This effect is minimized by increasing the output capacitor or inductor value.

## 7.5 Programming

### 7.5.1 Serial Interface Description

I2C™ is a 2-wire serial interface developed by Philips Semiconductor, now NXP Semiconductors (see I²C-Bus Specification, Version .6, 2014). The bus consists of a data line (SDA) and a clock line (SCL) with pullup structures. When the bus is *idle*, both SDA and SCL lines are pulled high. All the I²C-compatible devices connect to the I²C bus through open-drain I/O pins, SDA and SCL. A *controller* device, usually a microcontroller or a digital signal processor, controls the bus. The controller is responsible for generating the SCL signal and device addresses. The controller also generates specific conditions that indicate the START and STOP of data transfer. A *target* device receives, transmits data, or both on the bus under control of the controller device.

The TPS6286x device works as a *target* and supports the following data transfer *modes*, as defined in the I²C-Bus Specification: standard mode (100 kbps), fast mode (400 kbps), and fast mode plus (1 Mbps). The interface adds flexibility to the power supply solution, enabling most functions to be programmed to new values depending on the instantaneous application requirements. Register contents remain intact as long as the input voltage remains above 1.8 V.

The data transfer protocol for standard and fast modes is exactly the same, therefore, the modes are referred to as F/S-mode in this document. The protocol for high-speed mode is different and must not be used.

TI recommends that the I²C controller initiates a STOP condition on the I²C bus after the initial power up of SDA and SCL pullup voltages to make sure of reset of the I²C engine.

### 7.5.2 Standard- and Fast-Mode Protocol

The controller initiates data transfer by generating a start condition. The start condition is when a high-to-low transition occurs on the SDA line while SCL is high, as shown in Figure 7-3. All I²C-compatible devices recognize a start condition.

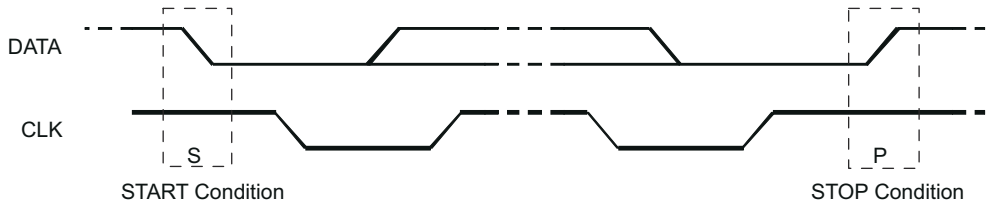



**Figure 7-3. START and STOP Conditions**

The controller then generates the SCL pulses, and transmits the 7-bit address and the read/write direction bit R/W on the SDA line. During all transmissions, the controller makes sure that data is valid. A valid data condition requires the SDA line to be stable during the entire high period of the clock pulse (see Figure 7-4). All devices recognize the address sent by the controller and compare to the internal fixed addresses. Only the target device with a matching address generates an acknowledge (see Figure 7-5) by pulling the SDA line low during the entire high period of the ninth SCL cycle. Upon detecting this acknowledge, the controller knows that communication link with a target has been established.

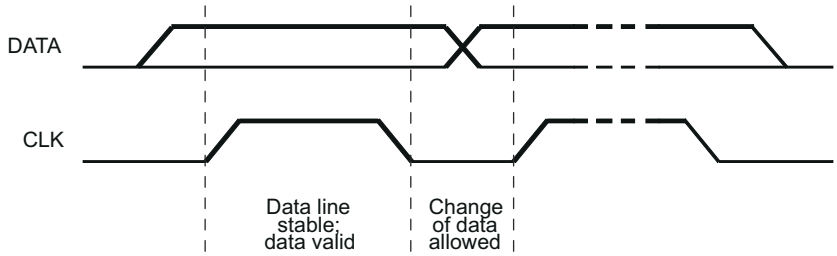



**Figure 7-4. Bit Transfer on the Serial Interface**

The controller generates further SCL cycles to either transmit data to the target (R/W bit 1) or receive data from the target (R/W bit 0). In either case, the receiver must acknowledge the data sent by the transmitter. An acknowledge signal can either be generated by the controller or by the target, depending on which one is the receiver. 9-bit valid data sequences consisting of 8-bit data and 1-bit acknowledge can continue as long as necessary.

To signal the end of the data transfer, the controller generates a stop condition by pulling the SDA line from low to high while the SCL line is high (see Figure 7-3). This action releases the bus and stops the communication link with the addressed target. All $I^2C$-compatible devices must recognize the stop condition. Upon the receipt of a stop condition, all devices know that the bus is released, and the devices wait for a start condition followed by a matching address.

Attempting to read data from register addresses not listed in this section results in 00h being read out.

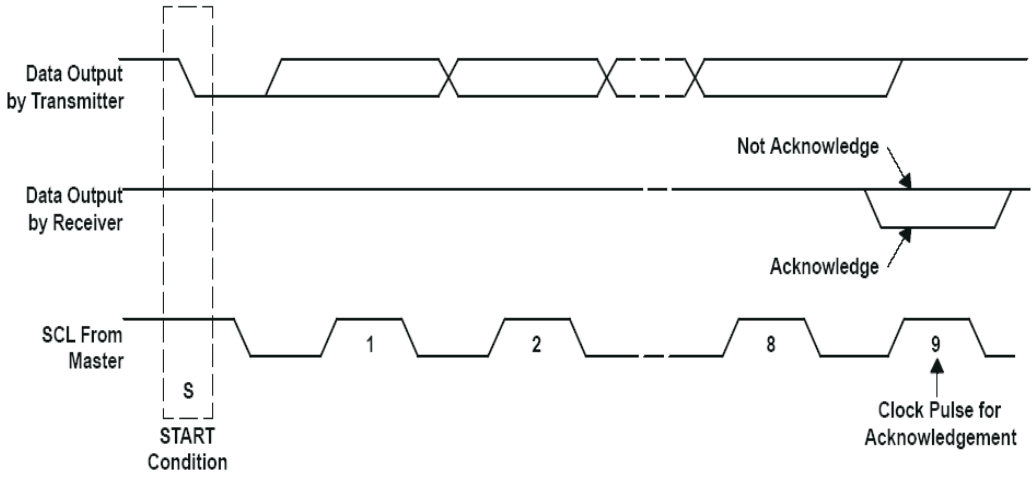



**Figure 7-5. Acknowledge on the $I^2C$ Bus**

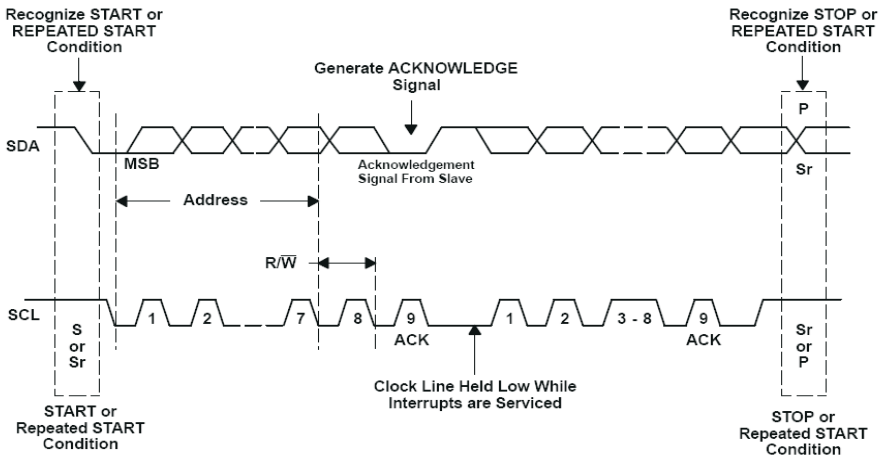



**Figure 7-6. Bus Protocol**

### *7.5.3 $I^2C$ Update Sequence*

The requires the following:

- A start condition
- A valid $I^2C$ address
- A register address byte
- A data byte for a single update

After the receipt of each byte, the device acknowledges by pulling the SDA line low during the high period of a single clock pulse. A valid $I^2C$ address selects the device. The device performs an update on the falling edge of the acknowledge signal that follows the LSB byte.

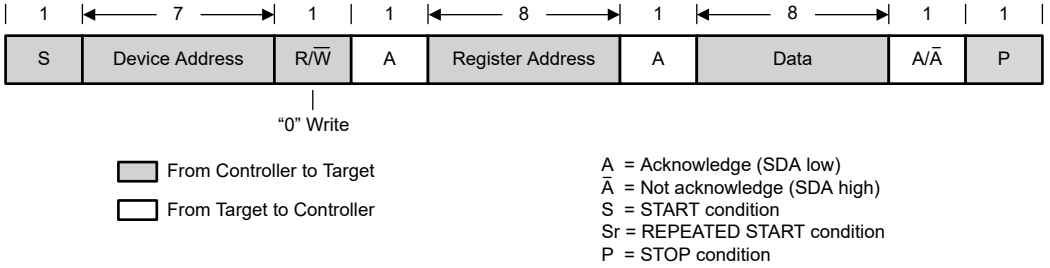



**Figure 7-7. "Write" Data Transfer Format in Standard-, Fast, and Fast-Plus Modes**

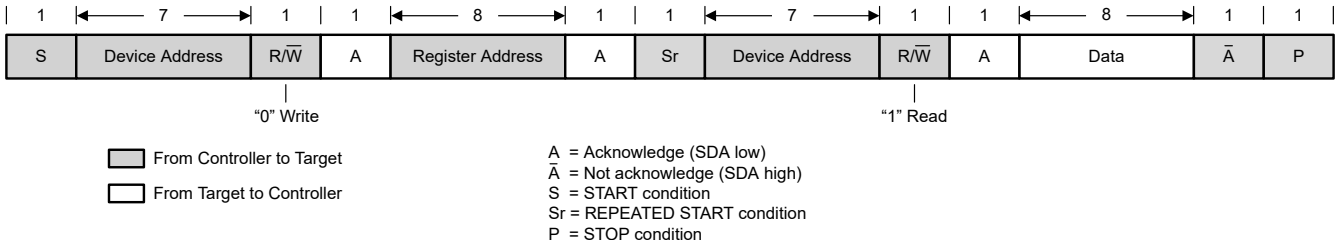



**Figure 7-8. "Read" Data Transfer Format in Standard-, Fast, and Fast-Plus Modes**

### *7.5.4 $I^2C$ Register Reset*

The $I^2C$ registers can be reset by the following:

- Pull the input voltage below 1.8 V (typ).
- A high to low transition on EN. The previous value of the "Enable Output Discharge" bit is latched until the next EN rising edge or pulling the input voltage below 1.0 V (typ).
- Set the Reset bit in the CONTROL register. When Reset is set to 1, all registers are reset to the default values and a new start-up begins immediately. After $t_{Delay}$, the $I^2C$ registers can be programmed again.

# 8 Register Map

**Table 8-1. Register Map**

| REGISTER ADDRESS (HEX) | REGISTER NAME | FACTORY DEFAULT (HEX) | DESCRIPTION |
|---|---|---|---|
| 0x01 | $V_{OUT}$ Register 1 | 0x10 | Sets the target output voltage |
| 0x02 | $V_{OUT}$ Register 2 | 0x38 | Sets the target output voltage |
| 0x03 | CONTROL Register | | Sets miscellaneous configuration bits |
| 0x05 | STATUS Register | 0x00 | Returns status flags, cleared on read-out |

## 8.1 I2C Address Byte

| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|
| 1 | x | x | x | x | x | x | R/W |

The target I2C address byte is the first byte received following the START condition from the controller device. The 7-bit target I2C address is internally set and has the value according the Device Comparison Table in Section 4 .

## 8.2 Register Address Byte

| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | D2 | D1 | D0 |

Following the successful acknowledgment of the target I2C address, the bus controller sends a byte to the device, which contains the address of the register to be accessed.

## 8.3 $V_{OUT}$ Register 1

**Table 8-2. $V_{OUT}$ Register 1 Description (Output Voltage Range 0.4 V to 1.9875 V)**

| REGISTER ADDRESS 0X01 READ/WRITE | | | |
|---|---|---|---|
| BIT | FIELD | VALUE (HEX) | OUTPUT VOLTAGE (TYP) |
| 6:0 | VO1_SET | 0x00 | 0.400V |
| | | 0x01 | 0.4125V |
| | | ... | |
| | | 0x10 | **0.600V** (default value for TPS628600/ TPS628610) |
| | | 0x24 | **0.85V** (default value for TPS628604) |
| | | 0x31 | **1.0125V** (default value for TPS628606) |
| | | ... | |
| | | 0x34 | **1.05V** (default value for TPS628603) |
| | | ... | |
| | | 0x70 | **1.8V** (default value for TPS628605) |
| | | 0x7E | 1.975V |
| | | 0x7F | 1.9875 V |

## 8.4 $V_{OUT}$ Register 2

**Table 8-3. $V_{OUT}$ Register 2 Description (Output Voltage Range 0.4 V to 1.9875 V)**

| REGISTER ADDRESS 0X02 READ/WRITE | | | |
|---|---|---|---|
| **BIT** | **FIELD** | **VALUE (HEX)** | **DESCRIPTION** |
| 7 | Operation Mode | 0x0 | Keep PFM/PWM selection as in CONTROL-Register |
| | | 0x1 | Sets the device in PWM operation for this Voltage selection (default value for TPS628605 and TPS628606) |
| **BIT** | **FIELD** | **VALUE (HEX)** | **OUTPUT VOLTAGE (TYP)** |
| 6:0 | VO2_SET | 0x00 | 0.400V |
| | | 0x01 | 0.4125V |
| | | ... | |
| | | 0x14 | **0.65V** (default value for TPS628603) |
| | | ... | |
| | | 0x31 | **1.0125V** (default value for TPS628606) |
| | | 0x38 | **1.10V** (default value for TPS628600/04 and TPS628610) |
| | | ... | |
| | | 0x70 | **1.8V** (default value for TPS628605) |
| | | 0x7E | 1.975V |
| | | 0x7F | 1.9875V |

## 8.5 CONTROL Register

**Table 8-4. CONTROL Register Description**

| REGISTER ADDRESS 0X03 READ/WRITE | | | | |
|---|---|---|---|---|
| **BIT** | **FIELD** | **TYPE** | **DEFAULT** | **DESCRIPTION** |
| 7 | Reset | W | 0 | 1 - Reset all registers to default.<br>This bit triggers a shutdown followed by a re-reading of the internal OTP settings and a new soft start. |
| 6 | Enable FPWM Mode during Output Voltage Change | R/W | 1 | 0 - Keep the current mode status during output voltage change.<br>1 - Force the device in FPWM during output voltage change. |
| 5 | Software Enable Device | R/W | 1 | 0 - Disable the device. All registers values are still kept.<br>1 - Re-enable the device with a new start-up without the $t_{Delay}$ period. |
| 4 | Enable FPWM Mode | R/W | 0 | 0 - Set the device in power save mode at light loads.<br>1 - Set the device in forced PWM mode at light loads. |
| 3 | Enable Output Discharge | R/W | 1 | 0 - Disable output discharge.<br>1 - Enable output discharge.<br>This setting is used for the next disable cycle (Software or Hardware). |
| 2 | Reserved | | | |
| 0:1 | Voltage Ramp Speed | R/W | 11(1) | 00 - 10mV/µs<br>01 - 5 mV/µs<br>10 - 1 mV/µs<br>11 - 0.1 mV/µs |

(1) The default value is programmed with 00 for TPS628603

## 8.6 STATUS Register

**Table 8-5. STATUS Register Description**

| REGISTER ADDRESS 0X05 READ ONLY(1) | | | | |
|---|---|---|---|---|
| **BIT** | **FIELD** | **TYPE** | **DEFAULT** | **DESCRIPTION** |
| 7:5 | Reserved | | | |
| 4 | Thermal Shutdown Tripped | R | 0 | 1: Thermal Shutdown has tripped since the last reading.<br>0: No Thermal Shutdown event occurred during the last reading. |
| 3 | Reserved | | | |
| 2 | Power Bad | R | 0 | 1: Output voltage is or was below 0.95xVO<br>0: No Power Bad event occurred since last reading |
| 1:0 | Reserved | | | |

(1) All bit values are latched until the device is reset, or the STATUS register is read. Then, the STATUS register is reset to the default values.

# 9 Application and Implementation

**Note**

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, as well as validating and testing their design implementation to confirm system functionality.

## 9.1 Application Information

The following section discusses the design of the external components to complete the power supply design for several input and output voltage options by using typical applications as a reference.

## 9.2 Typical Application, TPS628610

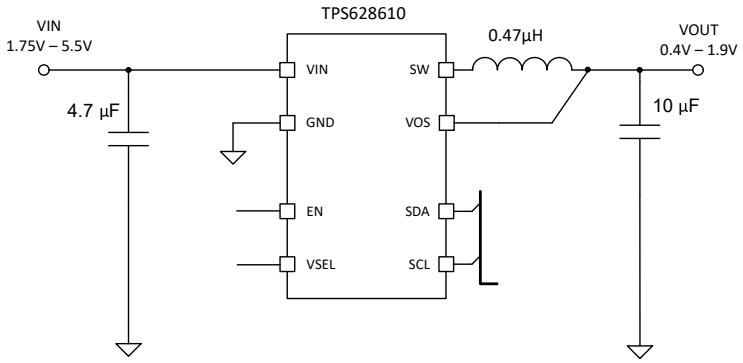



**Figure 9-1. TPS628610, Typical Application**

### *9.2.1 Design Requirements*

Table 9-1 shows the list of components for the application circuit and the characteristic application curves.

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

| REFERENCE | DESCRIPTION | VALUE | SIZE [L x W X T] | MANUFACTURER(1) |
|---|---|---|---|---|
| TPS628610 | Step down converter, 1 A | | 1.4 mm × 0.70 mm × 0.4 mm maximum | Texas Instruments |
| $C_{IN}$ | Ceramic capacitor, GRM155R60J475ME47D | 4.7 µF | 0402 (1 mm × 0.5 mm × 0.6 mm maximum) | Murata |
| $C_{OUT}$ | Ceramic capacitor, GRM155R60J106ME15D | 10 µF | 0402 (1 mm × 0.5 mm × 0.65 mm maximum) | Murata |
| L | Inductor DFE18SANR47MG0L | 0.47 µH | 0603 (1.6 mm × 0.8 mm × 1.0 mm maximum) | Murata |

(1) See *Third-party Products Disclaimer*.

### 9.2.2 Detailed Design Procedure

#### 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 the 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 Equation 1.

Equation 2 calculates the maximum inductor current under static load conditions. The saturation current of the inductor must be rated higher than the maximum inductor current, as calculated with Equation 2. TI recommends this rating 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

Table 9-2 shows a list of possible inductors.

**Table 9-2. List of Possible Inductors**

| INDUCTANCE [µH] | INDUCTOR SERIES | SIZE IMPERIAL (METRIC) | DIMENSIONS L × W × T | SUPPLIER(1) |
|---|---|---|---|---|
| 0.47 | DFE18SAN_G0 | 0603 (1608) | 1.6 mm × 0.8 mm × 1.0 mm maximum | Murata |
| 0.47 | HTEB16080F | 0603 (1608) | 1.6 mm × 0.8 mm × 0.6 mm maximum | Cyntec |
| 0.47 | HTET1005FE | 0402 (1005) | 1.0 mm × 0.5 mm × 0.65 mm maximum | Cyntec |
| 0.47 | TFM160808ALC | 0603 (1608) | 1.6 mm × 0.8 mm × 0.8 mm maximum | TDK |

(1) See *Third-party Products Disclaimer*

#### 9.2.2.2 Output Capacitor Selection

The DCS-Control scheme of the TPS6286x 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 inductor and output capacitor together provide a low-pass filter. Table 9-3 outlines possible inductor and capacitor value combinations to simplify this process.

**Table 9-3. Recommended LC Output Filter Combinations**

| DEVICE | NOMINAL INDUCTOR VALUE (µH) | NOMINAL OUTPUT CAPACITOR VALUE (µF) | | | |
|---|---|---|---|---|---|
| | | 4.7 µF | 10 µF | 2 × 10 µF | 22 µF |
| TPS62860x | 0.47(1) | √ | √(3) | √ | √ |
| | 1.0(2) | √ | √(3) | √ | √ |

(1) TI recommends an effective inductance range of 0.33 µH to 0.82 µH. TI recommends an effective capacitance range of 2 µF to 26 µF.
(2) TI recommends an effective inductance range of 0.7 µH to 1.2 µH. TI recommends an effective capacitance range of 3 µF to 26 µF.
(3) Typical application configuration. Other check marks indicate alternative filter combinations.

#### 9.2.2.3 Input Capacitor Selection

Because the buck converter has a pulsating input current, a low ESR ceramic 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 (such as a coin cell), TI recommends a larger input buffer capacitor ≥10 µF to avoid voltage drops during start-up and load transients. The input capacitance can be increased without any limit for better input voltage filtering. The leakage current of the input capacitor adds to the overall current consumption.

Table 9-4 shows a selection of input and output capacitors.

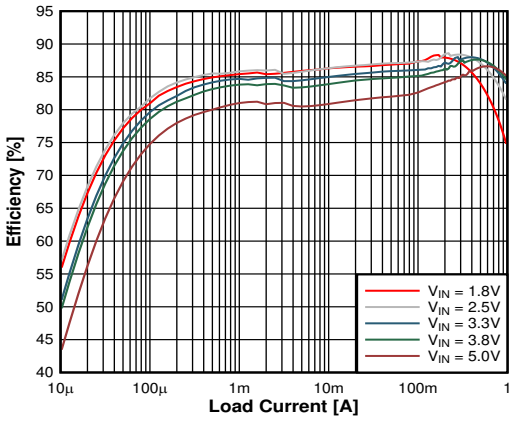
**Table 9-4. Capacitor Options**

| CAPACITANCE [µF] | CAPACITOR PART NUMBER | SIZE IMPERIAL (METRIC) | DIMENSIONS L × W × T | SUPPLIER(1) |
|---|---|---|---|---|
| 4.7 | GRM155R60J475ME47D | 0402 (1005) | 1.0 mm × 0.5 mm × 0.6 mm maximum | Murata |
| 4.7 | GRM035R60J475ME15 | 0201 (0603) | 0.6 mm × 0.3 mm × 0.55 mm maximum | Murata |
| 10 | GRM155R60J106ME15D | 0402 (1005) | 1.0 mm × 0.5 mm × 0.65 mm maximum | Murata |

(1) See *Third-party Products Disclaimer*.

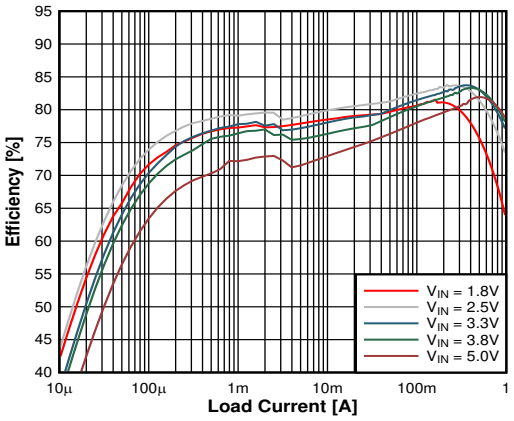
### 9.2.3 Application Curves

$V_{IN}$ = 3.8 V, $V_{OUT}$ = 1.1 V, $T_A$ = 25°C, unless otherwise noted



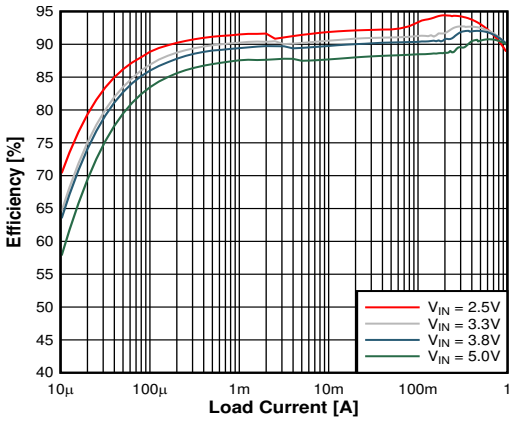

$V_{OUT}$ = 1.1 V Auto Power Save Mode

**Figure 9-2. Efficiency**



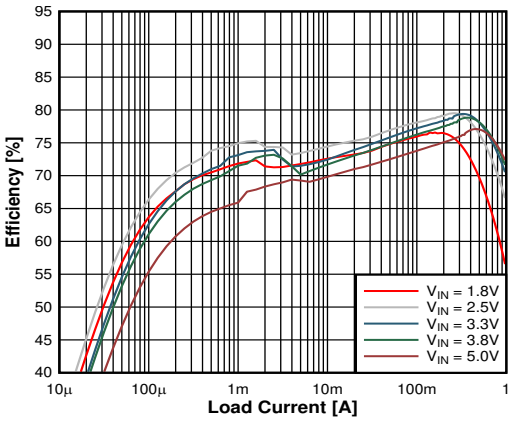

$V_{OUT}$ = 0.6 V Auto Power Save Mode

**Figure 9-3. Efficiency**



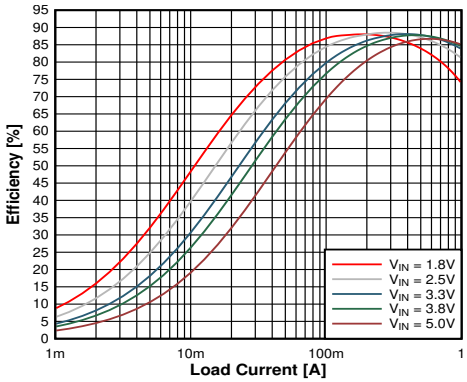

$V_{OUT}$ = 1.9875 V Auto Power Save Mode

**Figure 9-4. Efficiency**



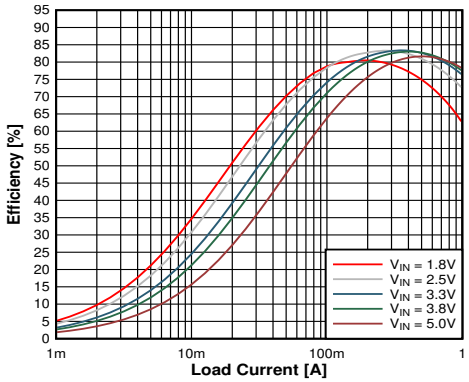

$V_{OUT}$ = 0.4 V Auto Power Save Mode

**Figure 9-5. Efficiency**



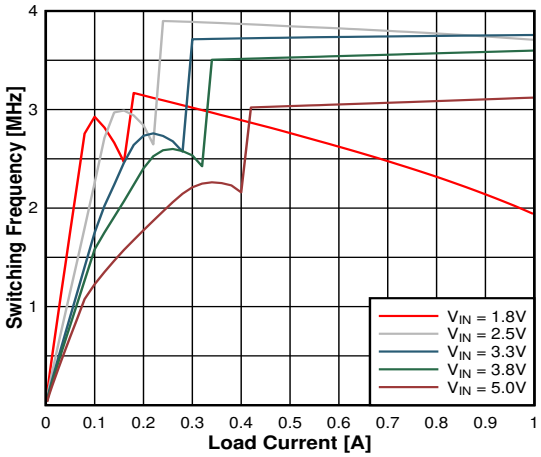

$V_{OUT}$ = 1.1 V Forced PWM Operation

**Figure 9-6. Efficiency, Inductor Comparison**



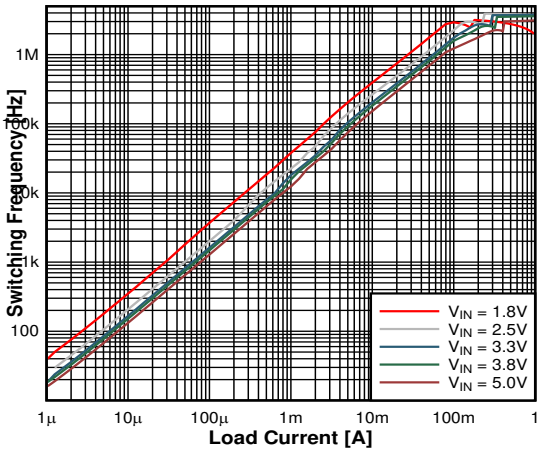

$V_{OUT}$ = 0.6 V Forced PWM operation

**Figure 9-7. Efficiency**



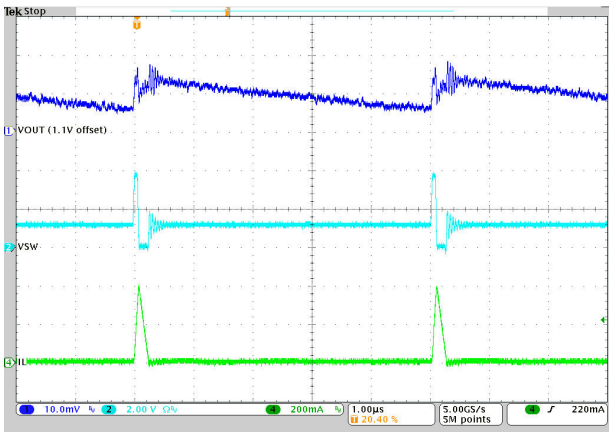

$V_{OUT}$ = 1.1 V Auto Power Save Mode

**Figure 9-8. Switching Frequency**



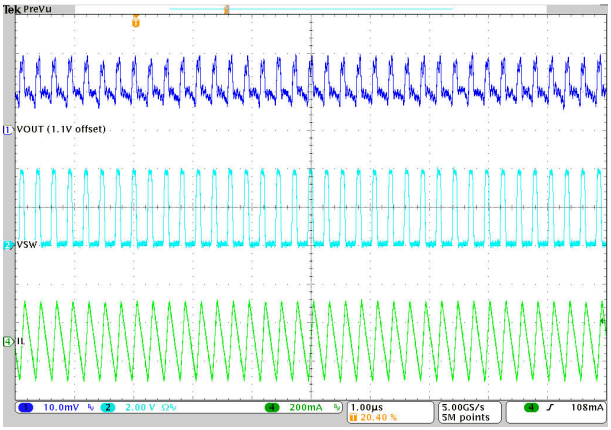

$V_{OUT}$ = 1.1 V

**Figure 9-9. Switching Frequency**



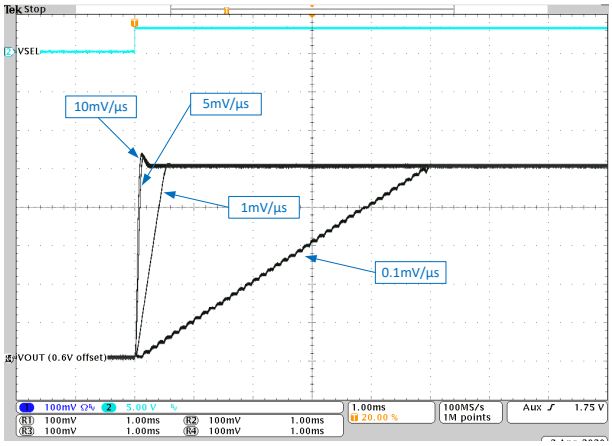

VSEL = HIGH

**Figure 9-10. PFM Mode Operation**



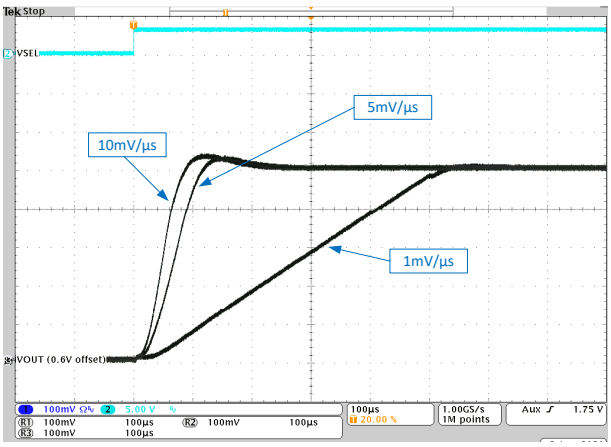

$I_{OUT}$ = 500 mA VSEL = HIGH

**Figure 9-11. PWM-Mode Operation**



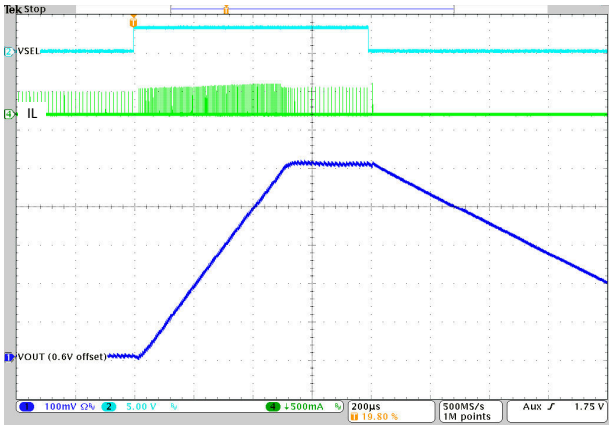

Default voltage setting

**Figure 9-12. DVS by VSEL, Different Ramp Speed Settings**



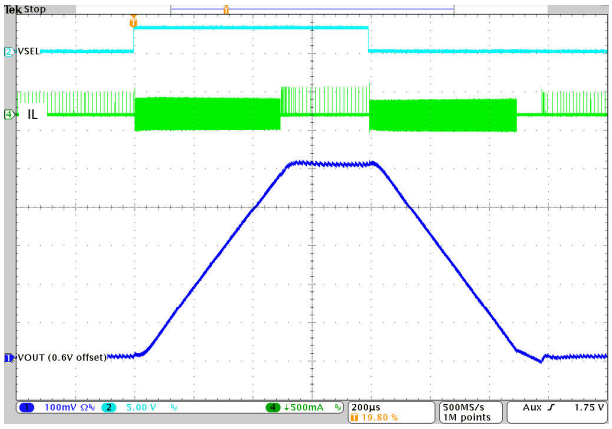

Default voltage setting

**Figure 9-13. DVS by VSEL, Different Ramp Speed Settings**




Power Save Mode is active

**Figure 9-14. Standard Operation: $V_{OUT}$ Change**




Power Save Mode is active

**Figure 9-15. FPWM-Mode During $V_{OUT}$ Change Enabled**

## 9.3 Typical Application, TPS628600, TPS62860x

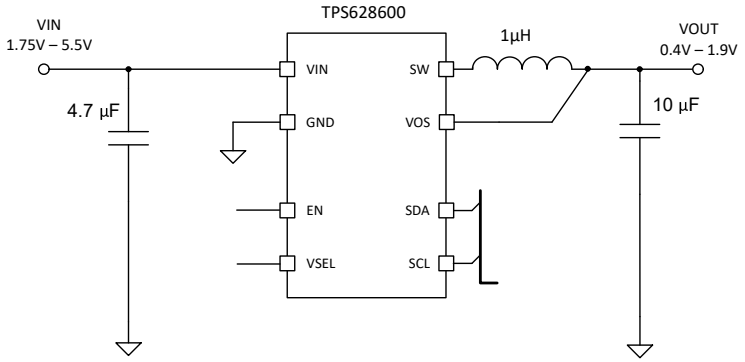



**Figure 9-16. TPS628600, Typical Application**

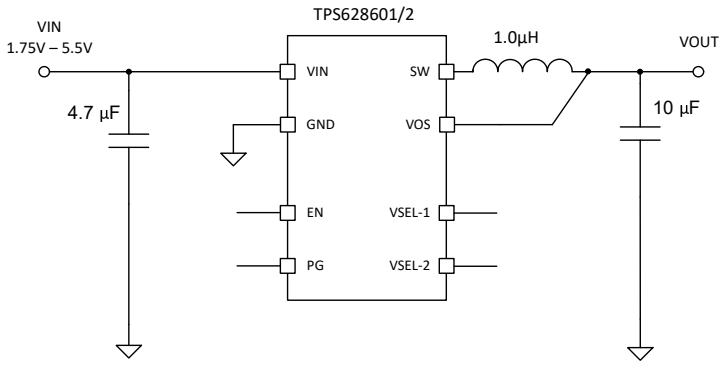



**Figure 9-17. TPS62860x, Typical Application**

### 9.3.1 Design Requirements

Table 9-5 shows the list of components for the application circuit and the characteristic application curves.

**Table 9-5. Components for Application Characteristic Curves**

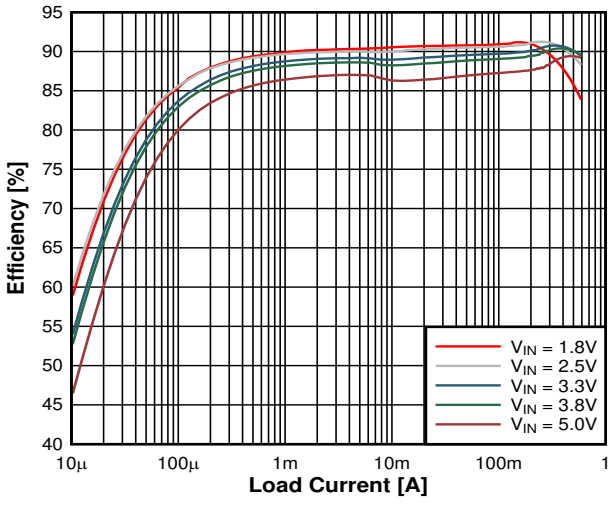
| REFERENCE | DESCRIPTION | VALUE | SIZE [L × W × T] | MANUFACTURER(1) |
|---|---|---|---|---|
| TPS628610 | Step down converter, 1 A | | 1.4 mm × 0.70 mm × 0.4 mm maximum | Texas Instruments |
| $C_{IN}$ | Ceramic capacitor, GRM155R60J475ME47D | 4.7 µF | 0402 (1 mm × 0.5 mm × 0.6 mm maximum) | Murata |
| $C_{OUT}$ | Ceramic capacitor, GRM155R60J106ME15D | 10 µF | 0402 (1 mm × 0.5 mm × 0.65 mm max.) | Murata |
| L | Inductor DFE201610E | 1 µH | 0805 (2.0 mm × 1.6 mm × 1.0 mm max.) | Murata |

(1) See *Third-party Products Disclaimer*.

### 9.3.2 Detailed Design Procedure

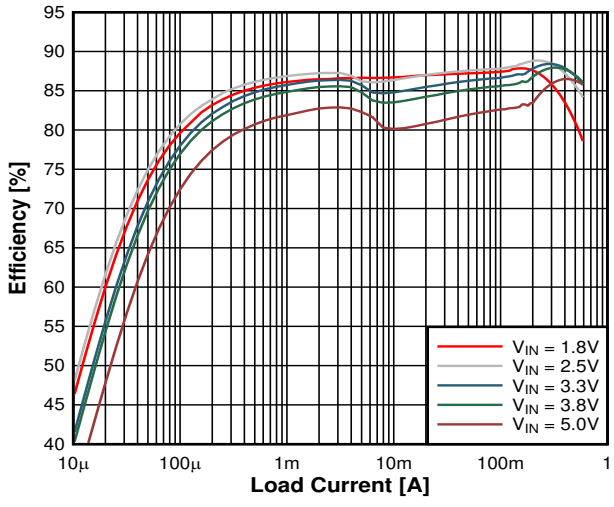
See *Section 9.2.2*.

### 9.3.3 Application Curves




$V_{OUT}$ = 1.1 V Auto Power Save Mode

**Figure 9-18. Efficiency**




$V_{OUT}$ = 0.7 V Auto Power Save Mode

**Figure 9-19. Efficiency**

## 9.4 Power Supply Recommendations

The power supply must provide a current rating according to the supply voltage, output voltage, and output current of the TPS6286x.

## 9.5 Layout

### 9.5.1 Layout Guidelines

The pinout of the TPS6286x converter has been optimized to enable a single top layer PCB routing of the converter and the critical passive components such as CIN, COUT, and L. This pinout allows the connection of tiny components such as 0201 (0603) size capacitors and 0402 (1005) size inductor. A design size smaller than 5 $mm^2$ can be achieved with a fixed output voltage.

- As for all switching power supplies, the layout is an important step in the design. A specified performance requires the correct on board layout.
- Provide a low inductance, low impedance ground path. Therefore, use wide and short traces for the main current paths.
- Place the input capacitor as close as possible to the VIN and GND pins of the converter. This is the most critical component placement.
- The VOS line is a sensitive, high impedance line and must be connected to the output capacitor and routed away from noisy components and traces (for example, SW line) or other noise sources.

### 9.5.2 Layout Example

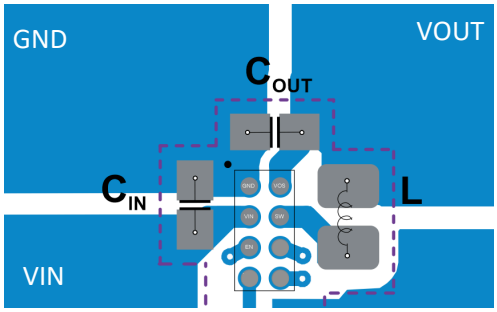



**Figure 9-20. PCB Layout Example**

# 10 Device and Documentation Support

## 10.1 Device Support

### *10.1.1 Third-Party Products Disclaimer*

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## 10.2 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. Click on *Notifications* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

## 10.3 Support Resources

TI E2E™ support forums are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

Linked content is 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.

## 10.4 Trademarks

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## 10.5 Electrostatic Discharge Caution

This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

## 10.6 Glossary

| | |
|---|---|
| TI Glossary | This glossary lists and explains terms, acronyms, and definitions. |

## 11 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

| Changes from Revision F (October 2023) to Revision G (January 2025) | Page |
|---|---|
| • Changed all instances of legacy terminology to controller and target where $I^2C$ is mentioned | 1 |
| • Added TPS628605 and TPS628606 to the data sheet | 1 |
| • Added TPS628605 and TPS628606 to *Device Comparison* table | 3 |
| • Added column for I2C Address to the *Device Comparison* table | 3 |
| • Added TPS628605 and TPS628606 to Table 5-1 | 4 |
| • Moved sub-sections Section 7.4.1, Section 7.4.2, Section 7.4.3, and Section 7.4.4 from the *Feature Description* into the *Device Functional Modes* | 13 |

| Changes from Revision E (April 2023) to Revision F (October 2023) | Page |
|---|---|
| • Added TPS628604 and removed TPS628602 in the data sheet | 1 |

## 12 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.

## 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) |
|---|---|---|---|---|---|---|---|---|---|
| TPS628600YCHR | Active | Production | DSBGA (YCH) \| 8 | 12000 \| LARGE T&R | Yes | SNAGCU | Level-1-260C-UNLIM | -40 to 125 | S |
| TPS628600YCHR.A | Active | Production | DSBGA (YCH) \| 8 | 12000 \| LARGE T&R | Yes | SNAGCU | Level-1-260C-UNLIM | -40 to 125 | S |
| TPS628601YCHR | Active | Production | DSBGA (YCH) \| 8 | 12000 \| LARGE T&R | Yes | SNAGCU | Level-1-260C-UNLIM | -40 to 125 | T |
| TPS628601YCHR.A | Active | Production | DSBGA (YCH) \| 8 | 12000 \| LARGE T&R | Yes | SNAGCU | Level-1-260C-UNLIM | -40 to 125 | T |
| TPS628603YCHR | Active | Production | DSBGA (YCH) \| 8 | 12000 \| LARGE T&R | Yes | SNAGCU | Level-1-260C-UNLIM | -40 to 125 | Q |
| TPS628603YCHR.A | Active | Production | DSBGA (YCH) \| 8 | 12000 \| LARGE T&R | Yes | SNAGCU | Level-1-260C-UNLIM | -40 to 125 | Q |
| TPS628604YCHR | Active | Production | DSBGA (YCH) \| 8 | 12000 \| LARGE T&R | Yes | SNAGCU | Level-1-260C-UNLIM | -40 to 125 | Q |
| TPS628604YCHR.A | Active | Production | DSBGA (YCH) \| 8 | 12000 \| LARGE T&R | Yes | SNAGCU | Level-1-260C-UNLIM | -40 to 125 | Q |
| TPS628605YCHR | Active | Production | DSBGA (YCH) \| 8 | 12000 \| LARGE T&R | Yes | SNAGCU | Level-1-260C-UNLIM | -40 to 125 | 3 |
| TPS628605YCHR.A | Active | Production | DSBGA (YCH) \| 8 | 12000 \| LARGE T&R | Yes | SNAGCU | Level-1-260C-UNLIM | -40 to 125 | 3 |
| TPS628606YCHR | Active | Production | DSBGA (YCH) \| 8 | 12000 \| LARGE T&R | Yes | SNAGCU | Level-1-260C-UNLIM | -40 to 125 | 2 |
| TPS628606YCHR.A | Active | Production | DSBGA (YCH) \| 8 | 12000 \| LARGE T&R | Yes | SNAGCU | Level-1-260C-UNLIM | -40 to 125 | 2 |
| TPS628610YCHR | Active | Production | DSBGA (YCH) \| 8 | 12000 \| LARGE T&R | Yes | SNAGCU | Level-1-260C-UNLIM | -40 to 125 | U |
| TPS628610YCHR.A | Active | Production | DSBGA (YCH) \| 8 | 12000 \| LARGE T&R | Yes | SNAGCU | Level-1-260C-UNLIM | -40 to 125 | U |

(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.

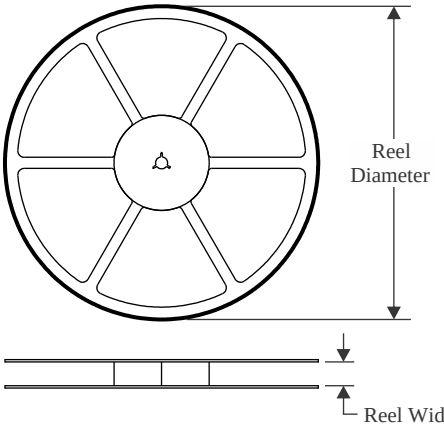
(5) **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will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

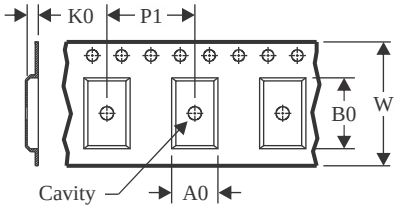
Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

## TAPE AND REEL INFORMATION

**REEL DIMENSIONS**

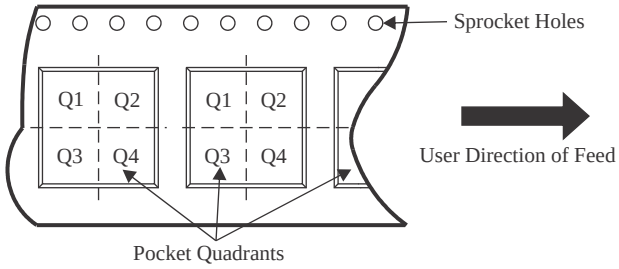



**TAPE DIMENSIONS**




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

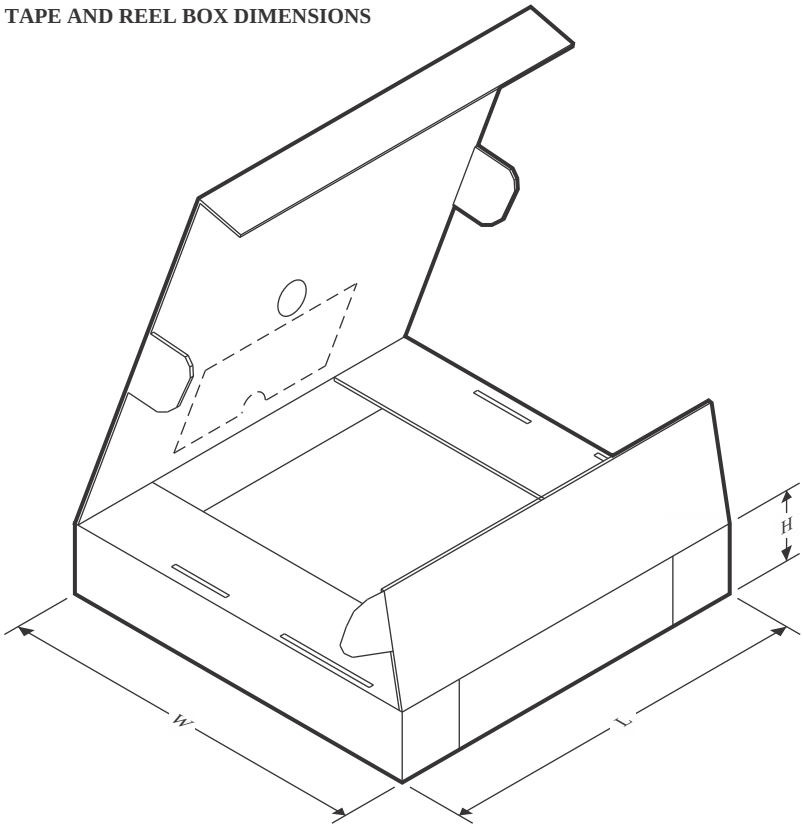
**QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE**




*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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TPS628600YCHR | DSBGA | YCH | 8 | 12000 | 180.0 | 8.4 | 0.81 | 1.53 | 0.43 | 2.0 | 8.0 | Q1 |
| TPS628601YCHR | DSBGA | YCH | 8 | 12000 | 180.0 | 8.4 | 0.81 | 1.53 | 0.43 | 2.0 | 8.0 | Q1 |
| TPS628603YCHR | DSBGA | YCH | 8 | 12000 | 180.0 | 8.4 | 0.81 | 1.53 | 0.43 | 2.0 | 8.0 | Q1 |
| TPS628604YCHR | DSBGA | YCH | 8 | 12000 | 180.0 | 8.4 | 0.81 | 1.53 | 0.43 | 2.0 | 8.0 | Q1 |
| TPS628605YCHR | DSBGA | YCH | 8 | 12000 | 180.0 | 8.4 | 0.81 | 1.53 | 0.43 | 2.0 | 8.0 | Q1 |
| TPS628606YCHR | DSBGA | YCH | 8 | 12000 | 180.0 | 8.4 | 0.81 | 1.53 | 0.43 | 2.0 | 8.0 | Q1 |
| TPS628610YCHR | DSBGA | YCH | 8 | 12000 | 180.0 | 8.4 | 0.81 | 1.53 | 0.43 | 2.0 | 8.0 | Q1 |

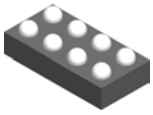
TAPE AND REEL BOX DIMENSIONS




*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|---|---|---|---|---|---|---|---|
| TPS628600YCHR | DSBGA | YCH | 8 | 12000 | 182.0 | 182.0 | 20.0 |
| TPS628601YCHR | DSBGA | YCH | 8 | 12000 | 182.0 | 182.0 | 20.0 |
| TPS628603YCHR | DSBGA | YCH | 8 | 12000 | 182.0 | 182.0 | 20.0 |
| TPS628604YCHR | DSBGA | YCH | 8 | 12000 | 182.0 | 182.0 | 20.0 |
| TPS628605YCHR | DSBGA | YCH | 8 | 12000 | 182.0 | 182.0 | 20.0 |
| TPS628606YCHR | DSBGA | YCH | 8 | 12000 | 182.0 | 182.0 | 20.0 |
| TPS628610YCHR | DSBGA | YCH | 8 | 12000 | 182.0 | 182.0 | 20.0 |

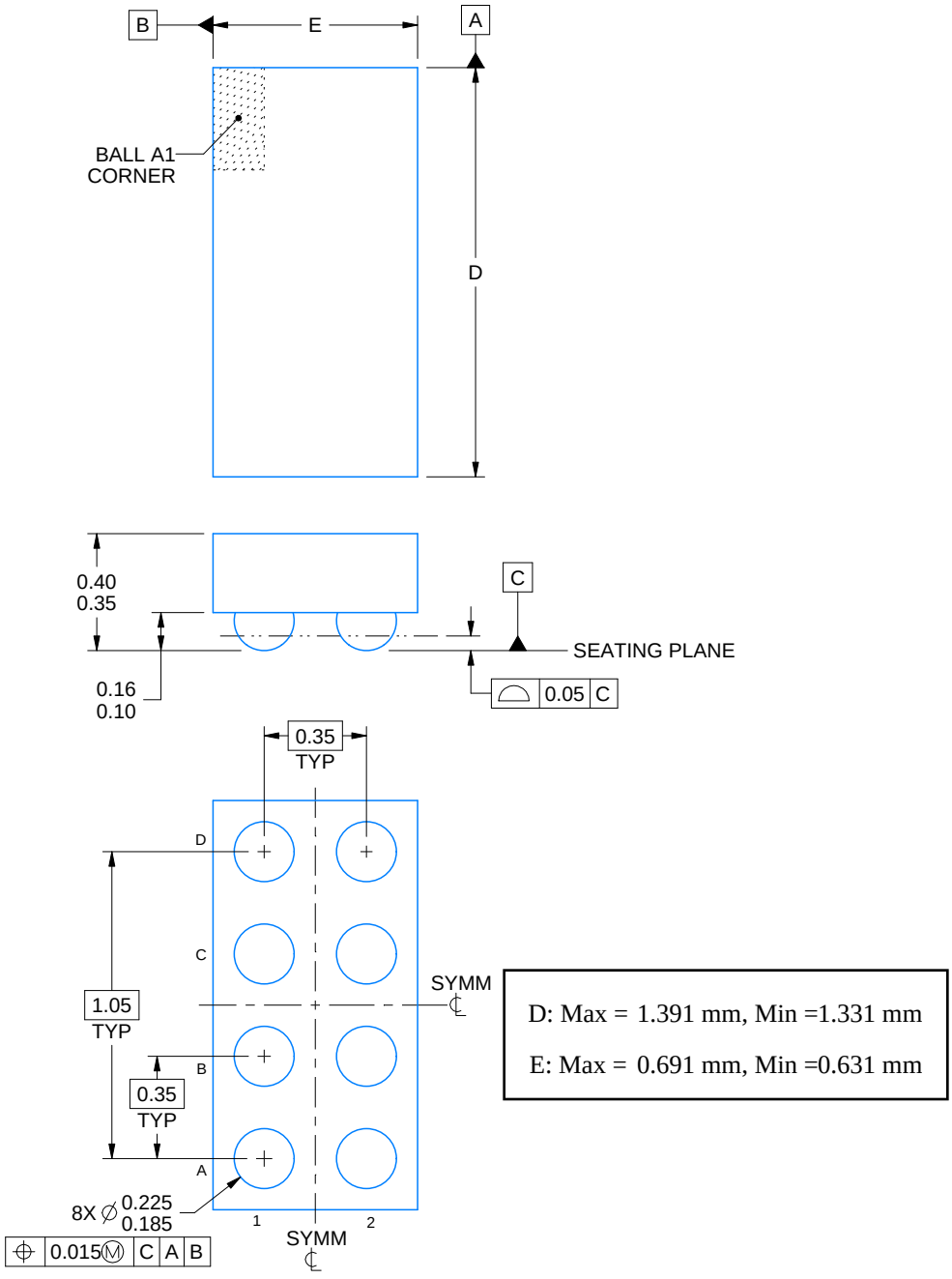
# YCH0008



# PACKAGE OUTLINE

## DSBGA - 0.4 mm max height

DIE SIZE BALL GRID ARRAY

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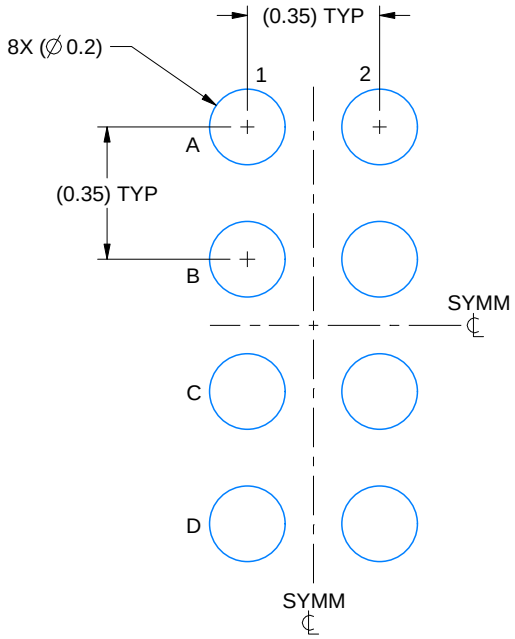
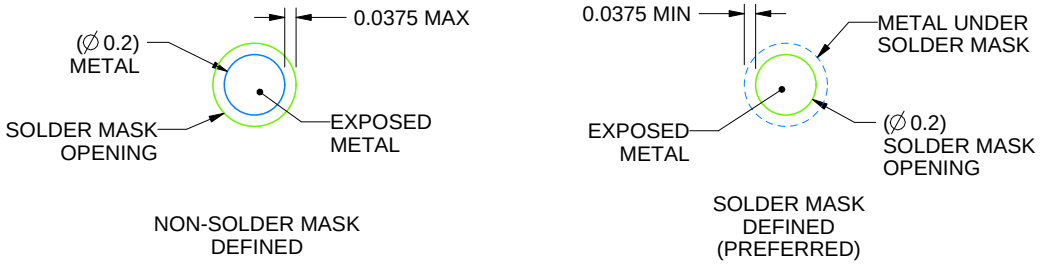
NOTES:

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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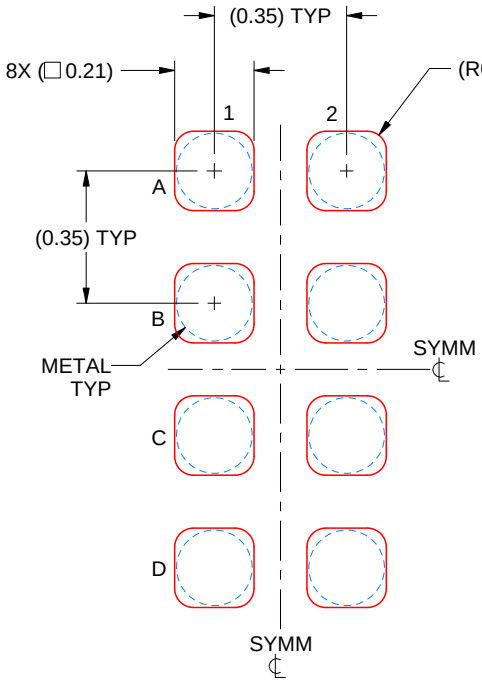
NOTES: (continued)

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 0.075 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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