



# TPS65142 LCD Bias Power Integrated with WLED Backlight Drivers

## 1 Features

- Integrated Bias and Backlight Power
- 2.3-V to 6-V Input Voltage Range for Bias
  - Up to 16.5 V Boost Converter with 1.8-A Switch Current
  - 1.2-MHz / 650-kHz Selectable Switching Frequency
  - Internal Compensation
  - Internal Soft-start at Power on
  - Reset Function ( $\overline{\text{XAO}}$  Signal)
  - Regulated VGH
  - Regulated VGL
  - Gate Voltage Shaping
  - LCD Discharge Function
- 150-mA Unity Gain VCOM Buffer
- 4.5-V to 24-V WLED Backlight Input Range
  - Integrated 1.5-A / 40-V MOSFET
  - Boost Output Tracks WLED Voltage
  - Internal Compensation
  - External Current Setting Input
  - 6 Current-Sink Channels of 25 mA
  - Better than 3% Current Matching
  - Up to 1000:1 PWM Dimming Range
- Overvoltage Protection
- Thermal Shutdown
- Undervoltage Lockout
- 32-Pin 6 mm × 3 mm QFN Package

## 2 Applications

- Note-PC TFT-LCD Panels
- Tablet TFT-LCD Panels

## 3 Description

The TPS65142 provides a compact solution to the bias power and the WLED backlight in note-pc TFT-LCD panels. The device features a boost converter, a positive charge pump regulator, and a negative charge pump regulator to power the source drivers and the gate drivers. A 150 mA unity-gain high-speed buffer is offered to drive the VCOM plane. Gate voltage shaping and the LCD discharge function are offered to improve the image quality. A reset function allows a proper reset of the TCON at the power on. The TPS65142 also offers the complete solution to driver up to 6 chains of WLEDs with 1000:1 ratio PWM dimming.

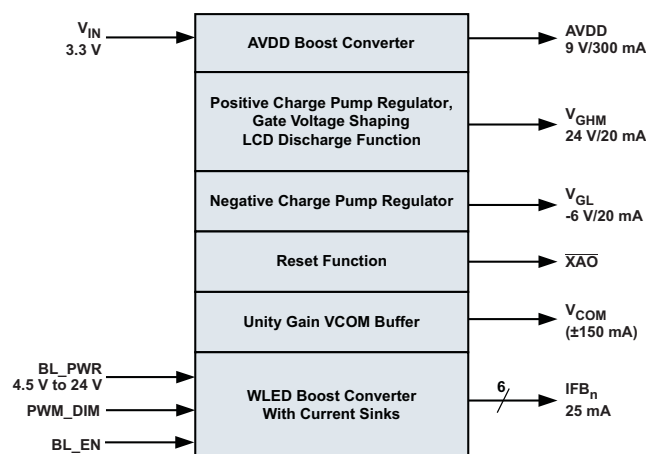
All features are integrated in a compact 6 x 3 mm<sup>2</sup> Thin QFN package.

### Device Information<sup>(1)</sup>

| PART NUMBER | PACKAGE   | BODY SIZE (NOM)   |
|-------------|-----------|-------------------|
| TPS65142    | WQFN (32) | 6.00 mm x 3.00 mm |

(1) For all available packages, see the orderable addendum at the end of the data sheet.

### Simplified Block Diagram



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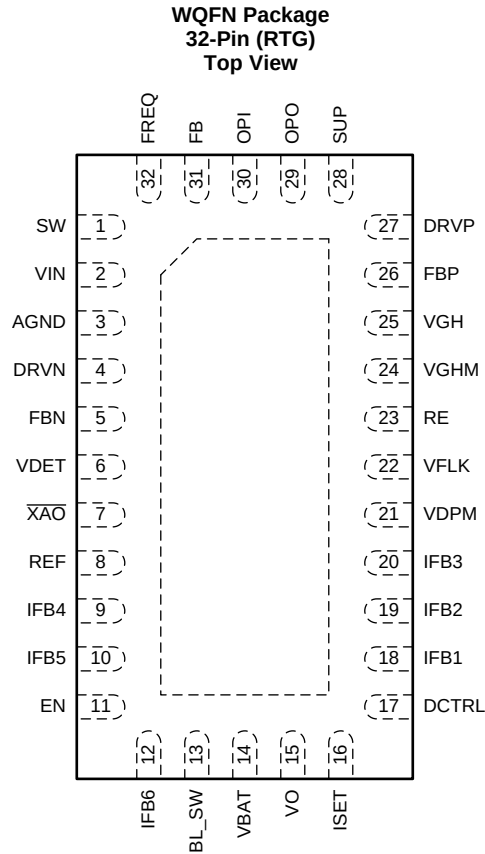
## 4 Revision History

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

| Changes from Revision A (November 2012) to Revision B                                                                                                                                                                                                        | Page |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| • Added the <i>ESD Ratings</i> table, <i>Feature Description</i> , <i>Application and Implementation</i> , <i>Power Supply Recommendations</i> , <i>Device and Documentation Support</i> , and <i>Mechanical, Packaging, and Orderable Information</i> ..... | 1    |
| • Deleted the <i>Ordering Information</i> table .....                                                                                                                                                                                                        | 4    |
| • Added <i>Timing Requirements</i> table. ....                                                                                                                                                                                                               | 8    |
| • Added sentence to the <i>Power Up Sequence</i> section: "To ensure proper start-up..." .....                                                                                                                                                               | 21   |
| • Changed <i>Figure 32</i> .....                                                                                                                                                                                                                             | 21   |

| Changes from Original (July 2011) to Revision A                                 | Page |
|---------------------------------------------------------------------------------|------|
| • Deleted COMP pin from ABSOLUTE MAXIMUM RATINGS .....                          | 4    |
| • Changed $I_{(IFB\_MAX)}$ TEST CONDITION IFB from 450 mV to 500 mV .....       | 8    |
| • Changed $I_{(IFB\_MAX)}$ min from 25 mA to 28 mA .....                        | 8    |
| • Changed $D_{max}$ min from 85% to 89% .....                                   | 8    |
| • Changed $V_{REF}$ from 3.15 V to 3.12 V in Negative Charge Pump section ..... | 16   |
| • Changed BL_PWR from 4.5V to 25V to 4.5V to 24V in <i>Figure 33</i> .....      | 22   |

## 5 Pin Configuration and Functions



### Pin Functions

| PIN   |     | I/O | DESCRIPTION                                                                                                                         |
|-------|-----|-----|-------------------------------------------------------------------------------------------------------------------------------------|
| NAME  | NO. |     |                                                                                                                                     |
| AGND  | 3   |     | Analog ground                                                                                                                       |
| BL_SW | 13  |     | The backlight boost converter switching node                                                                                        |
| DCTRL | 17  | I   | Backlight PWM dimming control input                                                                                                 |
| DRVN  | 4   | O   | Voltage driver of the negative charge pump                                                                                          |
| DRVP  | 27  |     | Voltage driver of positive charge pump                                                                                              |
| EN    | 11  | I   | Backlight enable input                                                                                                              |
| FB    | 31  | I   | AVDD Boost converter feedback pin                                                                                                   |
| FBN   | 5   | I   | Negative charge pump feedback pin                                                                                                   |
| FBP   | 26  | I   | Positive charge pump feedback pin                                                                                                   |
| FREQ  | 32  | I   | AVDD boost converter switching frequency selection: 1.2MHz when $V_{(FREQ)} = V_{IN}$ and 650 kHz when $V_{(FREQ)} = \text{ground}$ |
| IFB1  | 18  | I   | Channel 1 of the WLED backlight current sink                                                                                        |
| IFB2  | 19  | I   | Channel 2 of the WLED backlight current sink                                                                                        |
| IFB3  | 20  | I   | Channel 3 of the WLED backlight current sink                                                                                        |
| IFB4  | 9   | I   | Channel 4 of the WLED backlight current sink                                                                                        |
| IFB5  | 10  | I   | Channel 5 of the WLED backlight current sink                                                                                        |
| IFB6  | 12  | I   | Channel 6 of the WLED backlight current sink                                                                                        |
| ISET  | 16  | I   | WLED current sink level programming input                                                                                           |
| OPI   | 30  | I   | Input voltage of VCOM Buffer                                                                                                        |

## Pin Functions (continued)

| PIN                     |      | I/O | DESCRIPTION                                                                                                                                                                                            |
|-------------------------|------|-----|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| NAME                    | NO.  |     |                                                                                                                                                                                                        |
| OPO                     | 29   | O   | Output voltage of VCOM Buffer                                                                                                                                                                          |
| PGND                    | ePAD |     | Exposed pad that serves as the power ground for both boost converters                                                                                                                                  |
| RE                      | 23   |     | Sets the slope for the gate shaping function. Pin for external Resistor                                                                                                                                |
| REF                     | 8    | O   | Reference voltage for the negative charge pump                                                                                                                                                         |
| SUP                     | 28   | I   | Supply pin of the gate shaping and operational amplifier blocks. Connected as well to the overvoltage protection comparator. This pin needs to be connected to the output of the AVDD boost converter. |
| SW                      | 1    |     | Switch pin of the AVDD boost converter                                                                                                                                                                 |
| VBAT                    | 14   | I   | Input of the backlight boost converter                                                                                                                                                                 |
| VDET                    | 6    | I   | Reset IC threshold pin (Voltage divider)                                                                                                                                                               |
| VDPM                    | 21   | O   | Sets the delay to enable VGHM Output. Pin for external capacitor. Floating if no delay needed                                                                                                          |
| VFLK                    | 22   | I   | Charge/discharge signal for VGHM                                                                                                                                                                       |
| VGH                     | 25   | I   | Input for positive Charge Pump                                                                                                                                                                         |
| VGHM                    | 24   | O   | Output for gate-high modulation                                                                                                                                                                        |
| VIN                     | 2    | I   | Input supply pin                                                                                                                                                                                       |
| VO                      | 15   | O   | The output of the backlight boost converter                                                                                                                                                            |
| $\overline{\text{XAO}}$ | 7    | O   | Reset IC output pulling down $\overline{\text{XAO}}$ pin when active.                                                                                                                                  |

## 6 Specifications

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

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

|                              |                                                          | VALUE                             |     | UNIT |
|------------------------------|----------------------------------------------------------|-----------------------------------|-----|------|
|                              |                                                          | MIN                               | MAX |      |
| Voltage                      | Input voltage range                                      | −0.3                              | 6.5 | V    |
|                              | FB, FREQ, VDPM, VFLK, VDET, FBN, $\overline{\text{XAO}}$ | −0.3                              | 6.5 | V    |
|                              | SW, OPI, OPO, SUP, DRV, EN, DCTRL, IFB1 to IFB6          | −0.3                              | 20  | V    |
|                              | REF, FBP and ISET                                        | −0.3                              | 3.6 | V    |
|                              | VGH, VGHM, RE                                            | −0.3                              | 35  | V    |
|                              | VBAT                                                     | −0.3                              | 24  | V    |
|                              | BL_SW and VO                                             | −0.3                              | 40  | V    |
| Continuous power dissipation |                                                          | See the Thermal Information Table |     |      |
| Storage temperature range    |                                                          | −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.

### 6.2 ESD Ratings

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

- (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

|                                                                         | MIN | TYP | MAX  | UNIT |
|-------------------------------------------------------------------------|-----|-----|------|------|
| V <sub>IN</sub> Input voltage range                                     | 2.3 |     | 6    | V    |
| V <sub>S</sub> AVDD Boost output voltage range <sup>(1)</sup>           |     |     | 16.5 | V    |
| V <sub>GH</sub> Positive charge pump output voltage range               |     |     | 32   | V    |
| V <sub>BAT</sub> Battery voltage range                                  | 4.5 |     | 24   | V    |
| V <sub>O</sub> WLED boost converter output voltage                      |     |     | 38   | V    |
| V <sub>GL</sub> Negative charge pump output voltage range               | –14 |     |      | V    |
| L <sub>1</sub> Inductor for the AVDD boost converter <sup>(2)</sup>     | 4.7 |     | 10   | μH   |
| L <sub>2</sub> Inductor for the WLED boost converter                    | 4.7 |     | 10   | μH   |
| C <sub>IN</sub> Input decoupling capacitor                              | 1   |     |      | μF   |
| C <sub>O1</sub> Output decoupling capacitor of the AVDD boost converter |     | 20  |      | μF   |
| C <sub>O2</sub> Output decoupling capacitor of the WLED boost converter | 2.2 |     | 10   | μF   |
| T <sub>A</sub> Operating ambient temperature                            | –40 |     | 85   | °C   |
| T <sub>J</sub> Operating junction temperature                           | –40 |     | 125  | °C   |

(1) Maximum output voltage is limited by the overvoltage protection and not the maximum power switch rating

(2) Refer to application section for further information.

### 6.4 Thermal Information

| THERMAL METRIC <sup>(1)</sup> |                                              | WQFN          | UNITS |
|-------------------------------|----------------------------------------------|---------------|-------|
|                               |                                              | RTG (32 PINS) |       |
| R <sub>θJA</sub>              | Junction-to-ambient thermal resistance       | 35.4          | °C/W  |
| R <sub>θJctop</sub>           | Junction-to-case (top) thermal resistance    | 19.9          |       |
| R <sub>θJB</sub>              | Junction-to-board thermal resistance         | 5.6           |       |
| ψ <sub>JT</sub>               | Junction-to-top characterization parameter   | 0.2           |       |
| ψ <sub>JB</sub>               | Junction-to-board characterization parameter | 5.4           |       |
| R <sub>θJcbot</sub>           | Junction-to-case (bottom) thermal resistance | 1.7           |       |

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

### 6.5 Electrical Characteristics

V<sub>IN</sub> = 3.3 V, V<sub>S</sub> = 9V, V<sub>GH</sub> = 20 V, V<sub>BAT</sub> = 10.8V, I<sub>ISSET</sub> = 15μA, V<sub>IFBX</sub> = 0.5V, EN = V<sub>IN</sub>, T<sub>A</sub> = –40°C to 85°C, typical values are at T<sub>A</sub> = 25°C (unless otherwise noted)

| PARAMETER            |                                      | TEST CONDITIONS                                       | MIN | TYP  | MAX  | UNIT |
|----------------------|--------------------------------------|-------------------------------------------------------|-----|------|------|------|
| <b>SUPPLY</b>        |                                      |                                                       |     |      |      |      |
| I <sub>Q(IN)</sub>   | Operating quiescent current into VIN | Device not switching                                  |     | 0.17 | 0.5  | mA   |
| I <sub>Q(VGH)</sub>  | Operating quiescent current into VGH | V <sub>GH</sub> = 20 V, VFLK not oscillating          |     | 22   | 40   | μA   |
| I <sub>Q(SUP)</sub>  | Operating quiescent current into SUP | Device not switching. V <sub>S</sub> = 9 V, EN = high |     | 2.8  |      | mA   |
|                      |                                      | Device not switching. V <sub>S</sub> = 9 V, EN = GND  |     | 2.5  |      |      |
| I <sub>SD(VIN)</sub> | Shutdown current into VIN            | V <sub>IN</sub> = 1.8 V, V <sub>S</sub> = GND         |     | 20   | 33   | μA   |
| I <sub>SD(VGH)</sub> | Shutdown current into VGH            | V <sub>IN</sub> = 1.8 V, V <sub>GH</sub> = 32 V       |     | 30   | 50   | μA   |
| I <sub>SD(SUP)</sub> | Shutdown current into SUP            | V <sub>IN</sub> = 1.8 V, V <sub>S</sub> = 16.5 V      |     | 3    | 5    | μA   |
| I <sub>Q(BAT)</sub>  | VBAT pin quiescent current           | WLED boost regulator switching, no load               |     |      | 0.2  | mA   |
| I <sub>SD(BAT)</sub> | VBAT pin shutdown current            | EN = GND                                              |     |      | 18   | μA   |
| I <sub>Q(VO)</sub>   | VO pin quiescent current             | V <sub>O</sub> = 35 V                                 |     |      | 75   | μA   |
| UVLO                 | VIN under voltage lockout threshold  | V <sub>IN</sub> falling                               | 1.9 |      | 2.1  | V    |
|                      |                                      | V <sub>IN</sub> rising                                |     |      | 2.2  |      |
|                      | VBAT under voltage lockout threshold | V <sub>BAT</sub> rising                               |     |      | 4.45 | V    |
|                      |                                      | V <sub>BAT</sub> falling                              | 3.9 |      |      |      |
|                      | UVLO voltage of WLED control circuit |                                                       |     | 2.2  | 2.5  | V    |

## Electrical Characteristics (continued)

$V_{IN} = 3.3\text{ V}$ ,  $V_S = 9\text{ V}$ ,  $V_{GH} = 20\text{ V}$ ,  $V_{BAT} = 10.8\text{ V}$ ,  $I_{ISET} = 15\mu\text{A}$ ,  $V_{IFBX} = 0.5\text{ V}$ ,  $EN = V_{IN}$ ,  $T_A = -40^\circ\text{C}$  to  $85^\circ\text{C}$ , typical values are at  $T_A = 25^\circ\text{C}$  (unless otherwise noted)

| PARAMETER                                  |                                            | TEST CONDITIONS                                                                                 | MIN                    | TYP   | MAX   | UNIT          |
|--------------------------------------------|--------------------------------------------|-------------------------------------------------------------------------------------------------|------------------------|-------|-------|---------------|
| <b>LOGIC SIGNALS FREQ, VFLK, EN, DCTRL</b> |                                            |                                                                                                 |                        |       |       |               |
| $V_{IH}$                                   | Logic high input voltage                   | $V_{IN} = 2.5\text{ V}$ to $6\text{ V}$                                                         | 2                      |       |       | V             |
| $V_{IL}$                                   | Logic low input voltage                    | $V_{IN} = 2.5\text{ V}$ to $6\text{ V}$                                                         |                        |       | 0.5   | V             |
| $I_{LKG}$                                  | Input leakage current of VFLK pin          | VFLK = $6\text{ V}$ , FREQ = GND                                                                |                        |       | 0.1   | $\mu\text{A}$ |
| $R_{PD}$                                   | Pull-down resistance for EN and DCTRL pins | EN = DCTRL = $3.3\text{ V}$                                                                     | 400                    | 800   | 1600  | k $\Omega$    |
| <b>AVDD BOOST CONVERTER</b>                |                                            |                                                                                                 |                        |       |       |               |
| $V_S$                                      | Output voltage boost <sup>(1)</sup>        |                                                                                                 | 7                      |       | 16.5  | V             |
| $V_{OVP}$                                  | Overvoltage protection                     | VS rising                                                                                       | 16.9                   | 18    | 19    | V             |
| $V_{FB}$                                   | Feedback regulation voltage                | $T_A = -40^\circ\text{C}$ to $85^\circ\text{C}$                                                 | 1.226                  | 1.24  | 1.254 | V             |
|                                            |                                            | $T_A = 25^\circ\text{C}$                                                                        | 1.23                   | 1.24  | 1.25  |               |
| $I_{FB}$                                   | Feedback input bias current                | $V_{FB} = 1.240\text{ V}$                                                                       |                        |       | 0.1   | $\mu\text{A}$ |
| $r_{DS(ON)}$                               | N-channel MOSFET on-resistance             | $V_{IN} = V_{GS} = 5\text{ V}$ , $I_{SW} = \text{current limit}$                                |                        | 0.13  | 0.38  | $\Omega$      |
|                                            |                                            | $V_{IN} = V_{GS} = 3.3\text{ V}$ , $I_{SW} = \text{current limit}$                              |                        | 0.15  | 0.44  |               |
| $I_{LKG(SW)}$                              | AVDD Boost converter SW leakage current    | $V_{IN} = 1.8\text{ V}$ , $V_{SW} = 17\text{ V}$ , Device not switching                         |                        |       | 30    | $\mu\text{A}$ |
| $I_{LIM}$                                  | N-Channel MOSFET current limit             | $V_{IN} = 2.5\text{ V}$ to $6\text{ V}$                                                         | 1.8                    | 2.5   | 3.2   | A             |
|                                            |                                            | $V_{IN} = 2.3\text{ V}$ to $2.5\text{ V}$                                                       | 1.5                    |       |       | A             |
| $f_{BOOST}$                                | Switching frequency                        | FREQ = high                                                                                     | 0.9                    | 1.2   | 1.5   | MHz           |
|                                            |                                            | FREQ = low                                                                                      | 470                    | 625   | 780   | kHz           |
| $T_{SS}$                                   | Softstart time                             | FREQ = high, $L_1 = 6.8\mu\text{H}$ , $C_{O1} = 2.0\mu\text{F}$ and $10\text{ mA}$ load current |                        | 2     |       | ms            |
|                                            | Line regulation                            | $V_{IN} = 2.5\text{ V} \dots 6\text{ V}$ , $I_{OUT} = 10\text{ mA}$                             |                        | 0.008 |       | %/V           |
|                                            | Load regulation                            | $I_{OUT} = 0\text{ mA} \dots 500\text{ mA}$                                                     |                        | 0.15  |       | %/A           |
| <b>VGH REGULATOR</b>                       |                                            |                                                                                                 |                        |       |       |               |
| $f_{SWP}$                                  | Switching frequency                        |                                                                                                 | $0.5 \times f_{BOOST}$ |       |       | MHz           |
| $V_{FBP}$                                  | Reference voltage of feedback              | $T_A = -40^\circ\text{C}$ to $85^\circ\text{C}$                                                 | 1.210                  | 1.240 | 1.270 | V             |
|                                            |                                            | $T_A = 25^\circ\text{C}$                                                                        | 1.221                  | 1.240 | 1.259 |               |
| $I_{FBP}$                                  | Feedback input bias current                | $V_{FBP} = 1.240\text{ V}$                                                                      |                        |       | 0.1   | $\mu\text{A}$ |
| $r_{DS(ON)P1}$                             | DRVP $R_{DS(ON)}$ (PMOS)                   | $V_S = 9\text{ V}$ , $I_{(DRVP)} = 40\text{ mA}$                                                |                        | 8     | 20    | $\Omega$      |
| $r_{DS(ON)N1}$                             | DRVP $R_{DS(ON)}$ (NMOS)                   | $V_S = 9\text{ V}$ , $I_{(DRVP)} = -40\text{ mA}$                                               |                        | 3     | 10    | $\Omega$      |
| <b>VGL REGULATOR</b>                       |                                            |                                                                                                 |                        |       |       |               |
| $f_{SWN}$                                  | Switching frequency                        |                                                                                                 | $0.5 \times f_{BOOST}$ |       |       | MHz           |
| $V_{REF}$                                  | Reference voltage                          |                                                                                                 | 3.05                   | 3.12  | 3.18  | V             |
| $V_{FBN}$                                  | Reference voltage of feedback              |                                                                                                 | -48                    | 0     | 48    | mV            |
| $I_{FBN}$                                  | Feedback input bias current                | $V_{FBN} = 0\text{ V}$                                                                          |                        |       | 0.1   | $\mu\text{A}$ |
| $r_{DS(ON)P2}$                             | DRVN $R_{DS(ON)}$ (PMOS)                   | $V_S = 9\text{ V}$ , $I_{(DRVN)} = 40\text{ mA}$                                                |                        | 8     | 20    | $\Omega$      |
| $r_{DS(ON)N2}$                             | DRVN $R_{DS(ON)}$ (NMOS)                   | $V_S = 9\text{ V}$ , $I_{(DRVN)} = -40\text{ mA}$                                               |                        | 3     | 10    | $\Omega$      |
| <b>GATE VOLTAGE SHAPING VGHM</b>           |                                            |                                                                                                 |                        |       |       |               |
| $I_{(DPM)}$                                | Capacitor charge current VDPM pin          |                                                                                                 | 17                     | 20    | 23    | $\mu\text{A}$ |
| $r_{DS(ON)M1}$                             | VGH to VGHM $r_{DS(ON)}$ (M1 PMOS)         | VFLK = low, $I_{(VGHM)} = 20\text{ mA}$                                                         |                        | 13    | 25    | $\Omega$      |
| $r_{DS(ON)M2}$                             | VGHM to RE $r_{DS(ON)}$ (M2 PMOS)          | VFLK = high, $I_{(VGHM)} = 20\text{ mA}$ , VGHM = $7.5\text{ V}$                                |                        | 13    | 25    | $\Omega$      |

(1) Maximum output voltage limited by the overvoltage protection and not the maximum power switch rating

## Electrical Characteristics (continued)

$V_{IN} = 3.3\text{ V}$ ,  $V_S = 9\text{ V}$ ,  $V_{GH} = 20\text{ V}$ ,  $V_{BAT} = 10.8\text{ V}$ ,  $I_{ISET} = 15\mu\text{A}$ ,  $V_{IFBX} = 0.5\text{ V}$ ,  $EN = V_{IN}$ ,  $T_A = -40^\circ\text{C}$  to  $85^\circ\text{C}$ , typical values are at  $T_A = 25^\circ\text{C}$  (unless otherwise noted)

| PARAMETER          |                                              | TEST CONDITIONS                                                       | MIN         | TYP  | MAX          | UNIT             |
|--------------------|----------------------------------------------|-----------------------------------------------------------------------|-------------|------|--------------|------------------|
| <b>RESET</b>       |                                              |                                                                       |             |      |              |                  |
| $V_{IN(DET)}$      | VIN voltage range for reset detection        |                                                                       | 1.6         |      | 6            | V                |
| $V_{(DET)}$        | Reset IC threshold                           | Falling                                                               | 1.074       | 1.1  | 1.126        | V                |
| $V_{(DET\_HYS)}$   | Reset IC threshold hysteresis                |                                                                       |             | 65   |              | mV               |
| $I_{(DET\_B)}$     | Reset IC input bias current                  | $V_{(DET)} = 1.1\text{ V}$                                            |             |      | 0.1          | $\mu\text{A}$    |
| $I_{XAO}$          | Reset sink current capability <sup>(2)</sup> | $V_{(XAO\_ON)} = 0.5\text{ V}$                                        | 1           |      |              | mA               |
| $I_{LKG(XAO)}$     | Reset leakage current                        | $V_{(XAO)} = V_{IN} = 3.3\text{ V}$                                   |             |      | 2            | $\mu\text{A}$    |
| <b>VCOM BUFFER</b> |                                              |                                                                       |             |      |              |                  |
| $V_{SUP}$          | SUP input supply range <sup>(3)</sup>        |                                                                       | 7           |      | 16.5         | V                |
| $I_B$              | Input bias current                           | $V_{CM} = V_{(OPI)} = V_{SUP}/2 = 4.5\text{ V}$                       | –1          |      | 1            | $\mu\text{A}$    |
| $V_{CM}$           | Common Mode Input Voltage Range              | $V_{OFFSET} = 10\text{ mV}$ , $I_{(OPO)} = 10\text{ mA}$              | 2           |      | $V_S - 2$    | V                |
| CMRR               | Common Mode Rejection Ratio <sup>(4)</sup>   | $V_{CM} = V_{(OPI)} = V_{(SUP)}/2 = 4.5\text{ V}$ , 1 MHz             |             | 66   |              | dB               |
| $A_{VOL}$          | Open Loop Gain <sup>(4)</sup>                | $V_{CM} = V_{(OPI)} = V_{(SUP)}/2 = 4.5\text{ V}$ , no load           |             | 90   |              | dB               |
| $V_{OL}$           | Output Voltage Swing Low                     | $I_{(OPO)} = 10\text{ mA}$                                            |             | 0.10 | 0.25         | V                |
| $V_{OH}$           | Output Voltage Swing High                    | $I_{(OPO)} = 10\text{ mA}$                                            | $V_S - 0.8$ |      | $V_S - 0.65$ | V                |
| $I_{SC}$           | Short Circuit Current                        | Source ( $V_{(OPI)} = 4.5\text{ V}$ , $V_{(OPO)} = \text{GND}$ )      | 150         |      |              | mA               |
|                    |                                              | Sink ( $V_{(OPI)} = 4.5\text{ V}$ , $V_{(OPO)} = 9\text{ V}$ )        | 150         |      |              |                  |
| $I_O$              | Output Current                               | Source ( $V_{(OPI)} = 4.5\text{ V}$ , $V_{(OFFSET)} = 15\text{ mV}$ ) |             | 150  |              | mA               |
|                    |                                              | Sink ( $V_{(OPI)} = 4.5\text{ V}$ , $V_{(OFFSET)} = 15\text{ mV}$ )   |             | 140  |              |                  |
| PSRR               | Power Supply Rejection Ratio <sup>(4)</sup>  |                                                                       |             | 40   |              | dB               |
| SR                 | Slew Rate <sup>(4)</sup>                     | $A_V = 1$ , $V_{(OPI)} = 2\text{ V}_{PP}$                             |             | 40   |              | V/ $\mu\text{s}$ |
| BW                 | –3 dB Bandwidth <sup>(4)</sup>               | $A_V = 1$ , $V_{(OPI)} = 60\text{ mV}_{PP}$                           |             | 50   |              | MHz              |

(2) External pull-up resistor to be chosen so that the current flowing into  $\overline{XAO}$  Pin ( $I_{XAO} = 0\text{ V}$ ) when active is below  $I_{(XAO)\text{ MIN}} = 1\text{ mA}$ .

(3) Maximum output voltage limited by the Overvoltage Protection and not the maximum Power Switch rating.

(4) Typical values are for reference only

## Electrical Characteristics (continued)

$V_{IN} = 3.3\text{ V}$ ,  $V_S = 9\text{ V}$ ,  $V_{GH} = 20\text{ V}$ ,  $V_{BAT} = 10.8\text{ V}$ ,  $I_{ISET} = 15\mu\text{A}$ ,  $V_{IFBx} = 0.5\text{ V}$ ,  $EN = V_{IN}$ ,  $T_A = -40^\circ\text{C}$  to  $85^\circ\text{C}$ , typical values are at  $T_A = 25^\circ\text{C}$  (unless otherwise noted)

| PARAMETER                                                        |                                                   | TEST CONDITIONS                                         | MIN   | TYP   | MAX   | UNIT             |
|------------------------------------------------------------------|---------------------------------------------------|---------------------------------------------------------|-------|-------|-------|------------------|
| <b>WLED CURRENT REGULATION</b>                                   |                                                   |                                                         |       |       |       |                  |
| $V_{(ISET)}$                                                     | ISET pin voltage                                  |                                                         | 1.204 | 1.229 | 1.253 | V                |
| $K_{(ISET)}$                                                     | Current multiple $I_{OUT}/I_{SET}$ <sup>(5)</sup> | ISET current = 20 $\mu\text{A}$                         |       | 1000  |       |                  |
| $I_{FB}$                                                         | Current accuracy <sup>(5)</sup>                   | ISET current = 20 $\mu\text{A}$                         | 19.4  | 20    | 20.6  | mA               |
| $K_m$                                                            | $(I_{max}-I_{min})/I_{AVG}$                       | ISET current = 20 $\mu\text{A}$                         |       | 1%    | 2.5%  |                  |
| $I_{LKG}$                                                        | IFB pin leakage current                           | IFB voltage = 20 V on all pins                          |       |       | 3     | $\mu\text{A}$    |
| $I_{(IFB\_MAX)}$                                                 | Current sink max output current                   | IFB = 500 mV                                            | 28    |       |       | mA               |
| <b>WLED BOOST OUTPUT REGULATION</b>                              |                                                   |                                                         |       |       |       |                  |
| $V_{(IFB\_L)}$                                                   | $V_O$ dial up threshold                           | Measured on $V_{(IFB)}$ min                             |       | 400   |       | mV               |
| $V_{(IFB\_H)}$                                                   | $V_O$ dial down threshold                         | Measured on $V_{(IFB)}$ min                             |       | 700   |       | mV               |
| $V_{(reg\_L)}$                                                   | Minimum $V_O$ regulation voltage                  |                                                         |       |       | 16    | V                |
| $V_{O(step)}$                                                    | $V_O$ stepping voltage                            |                                                         |       | 100   | 150   | mV               |
| <b>WLED BOOST REGULATOR POWER SWITCH</b>                         |                                                   |                                                         |       |       |       |                  |
| $R_{(PWM\_SW)}$                                                  | PWM FET on-resistance                             |                                                         |       | 0.2   | 0.45  | $\Omega$         |
| $I_{(LN\_NFET)}$                                                 | PWM FET leakage current                           | $V_{(BL\_SW)} = 35\text{ V}$ , $T_A = 25^\circ\text{C}$ |       |       | 1     | $\mu\text{A}$    |
| <b>WLED OSCILLATOR</b>                                           |                                                   |                                                         |       |       |       |                  |
| $f_S$                                                            | Oscillator frequency                              |                                                         | 0.9   | 1.0   | 1.2   | MHz              |
| $D_{max}$                                                        | Maximum duty cycle of WLED Boost                  | IFB = 0 V                                               | 89%   | 94%   |       |                  |
| $D_{min}$                                                        | Minimum duty cycle of WLED Boost                  |                                                         |       |       | 7%    |                  |
| <b>CURRENT LIMIT, OVER VOLTAGE AND SHORT CIRCUIT PROTECTIONS</b> |                                                   |                                                         |       |       |       |                  |
| $I_{LIM}$                                                        | N-Channel MOSFET current limit                    | $D = D_{MAX}$                                           | 1.5   |       | 3     | A                |
| $V_{OVP}$                                                        | VO overvoltage threshold                          | Measured on the VO pin                                  | 38    | 39    | 40    | V                |
| $V_{OVP(IFB)}$                                                   | IFB overvoltage threshold                         | Measured on the IFBx pin                                | 15    | 17    | 20    | V                |
| $V_{SC}$                                                         | Short circuit detection threshold                 | $V_{BAT} - V_O$ , $V_O$ ramp down                       |       | 1.7   | 2.5   | V                |
| $V_{SC(dly)}$                                                    | Short circuit detection delay during start up     |                                                         |       | 32    |       | ms               |
| <b>THERMAL SHUTDOWN</b>                                          |                                                   |                                                         |       |       |       |                  |
| $T_{SD}$                                                         | Thermal shutdown                                  | Temperature rising                                      |       | 150   |       | $^\circ\text{C}$ |
| $T_{SDHYS}$                                                      | Thermal shutdown hysteresis                       |                                                         |       | 14    |       | $^\circ\text{C}$ |

(5) Tested at  $T_A = 25^\circ\text{C}$  to  $85^\circ$ .

## 6.6 Timing Requirements

|                                                                                                                                                           | MIN | NOM | MAX | UNIT |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------|-----|-----|-----|------|
| $t_d$ Rising edge delay between $V_{BAT}$ and $V_{IN}$ , measured at their respective rising edge UVLO threshold voltages (see Figure 32). <sup>(1)</sup> | 0   |     |     | s    |

(1) This means that the voltage on the VBAT pin must exceed its UVLO threshold before the voltage on the VIN pin rises above its UVLO threshold.



## 6.7 Typical Characteristics

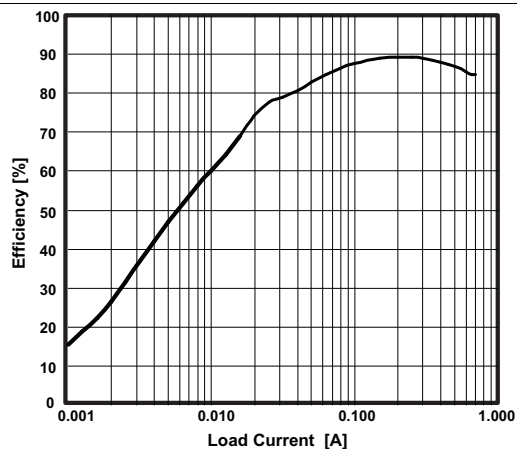


Figure 1. Boost Converter Efficiency vs Output Current

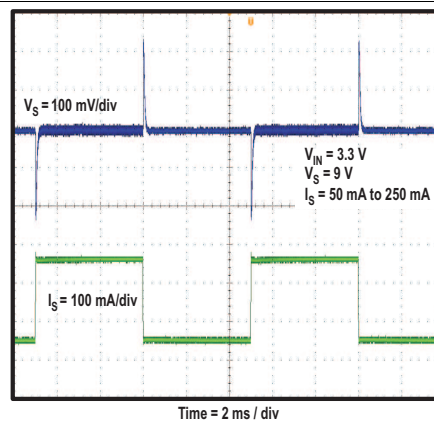


Figure 2. Boost Converter Load Transient Response

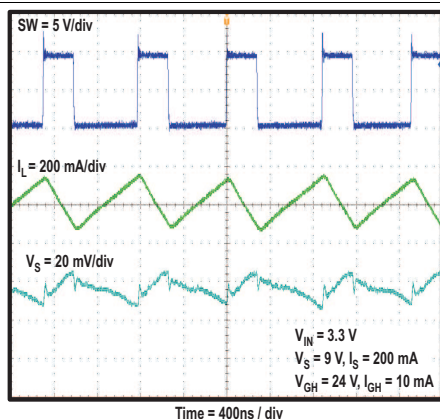


Figure 3. Boost Converter Continuous Conduction Mode

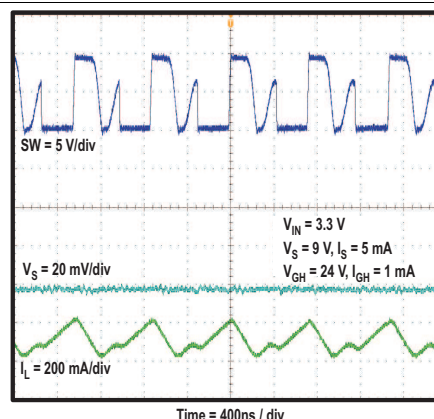


Figure 4. Boost Converter Discontinuous Conduction Mode

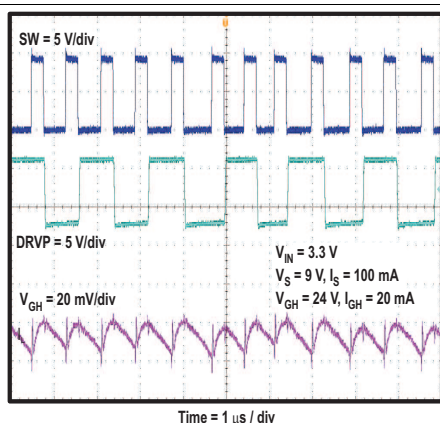


Figure 5. Positive Charge Pump Output Voltage Ripple

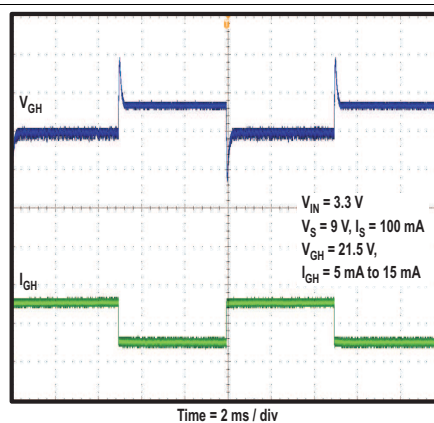


Figure 6. Positive Charge Pump Load Transient Response

## Typical Characteristics (continued)

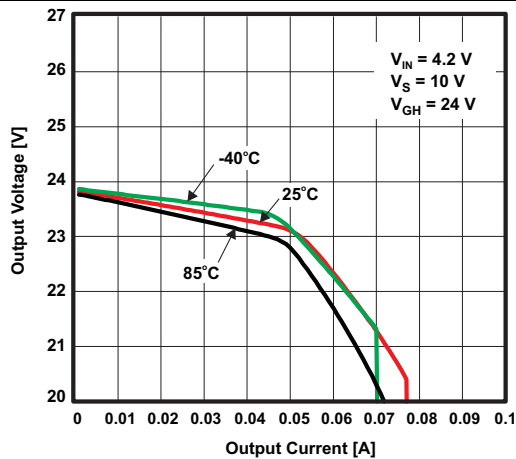


Figure 7. Positive Charge Pump Voltage vs Load Current

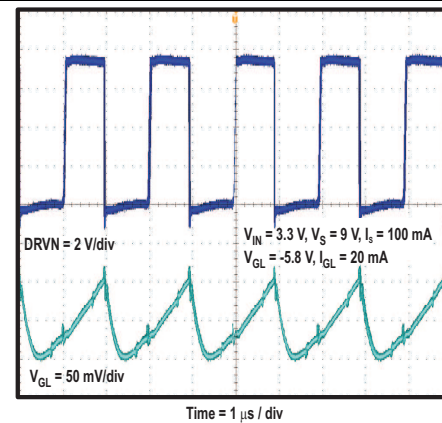


Figure 8. Negative Charge Pump Output Voltage Ripple

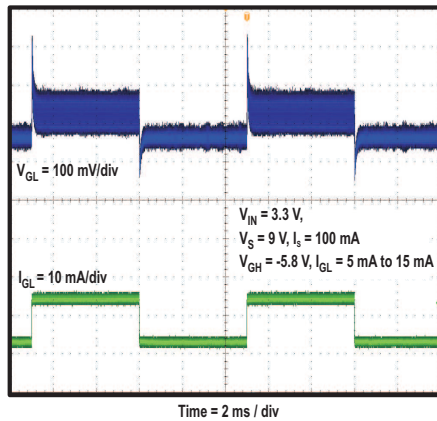


Figure 9. Negative Charge Pump Load Transient Response

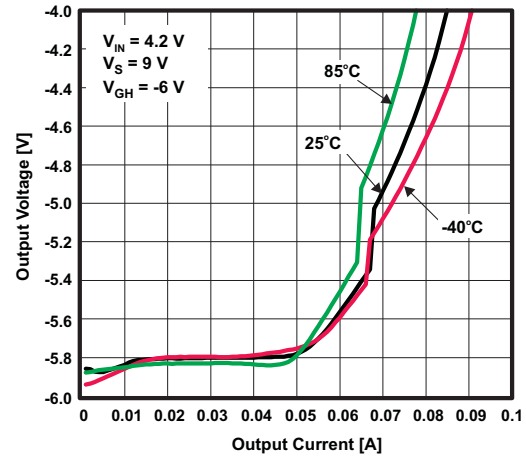


Figure 10. Negative Charge Pump Voltage vs Load Current

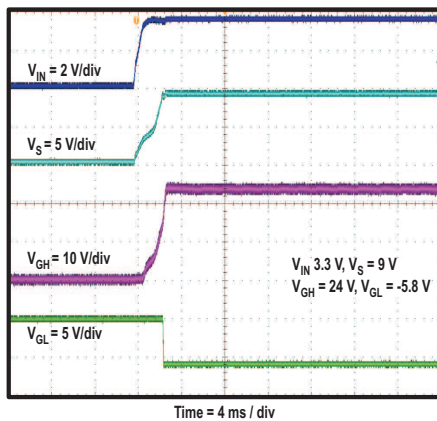


Figure 11. Power On Sequence

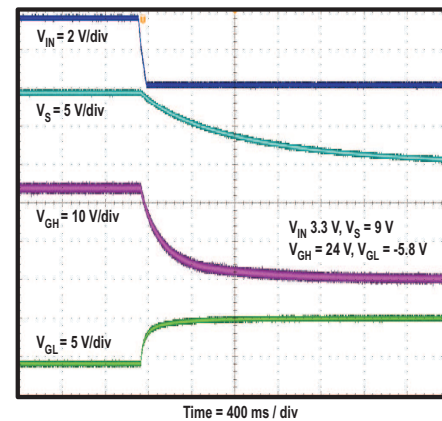


Figure 12. Power Off Sequence

## Typical Characteristics (continued)

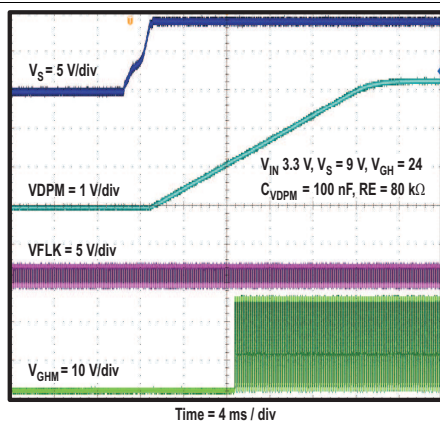


Figure 13. Power-On Sequence of VGHM

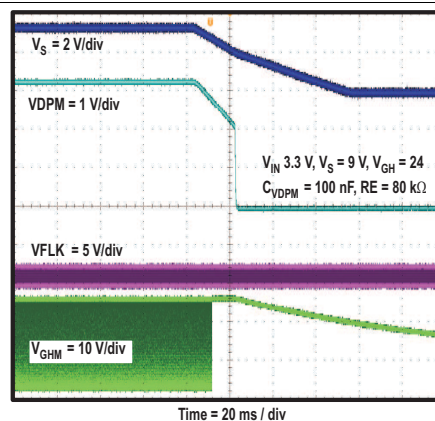


Figure 14. Power-Off Sequence of VGHM

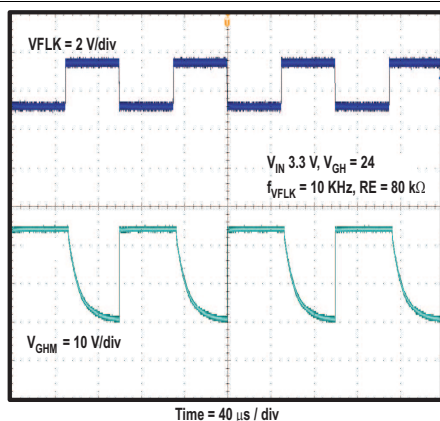


Figure 15. Gate Voltage Shaping

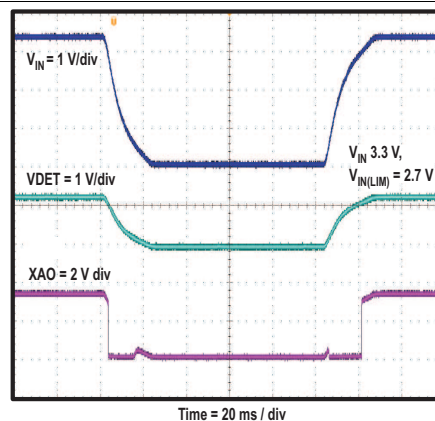


Figure 16.  $\overline{XAO}$  Signal

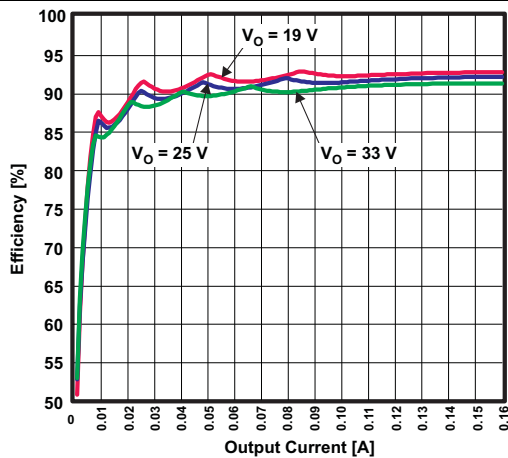


Figure 17. WLED Driver Efficiency vs Output Current

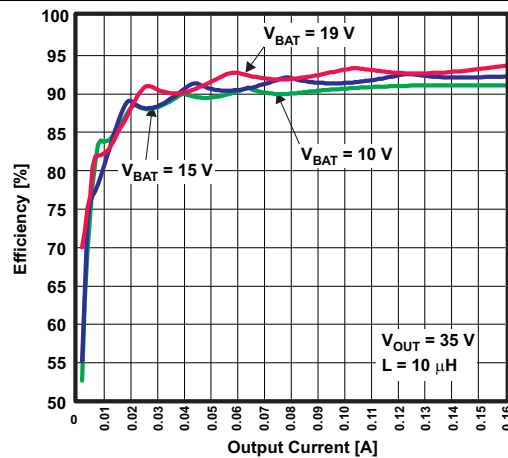
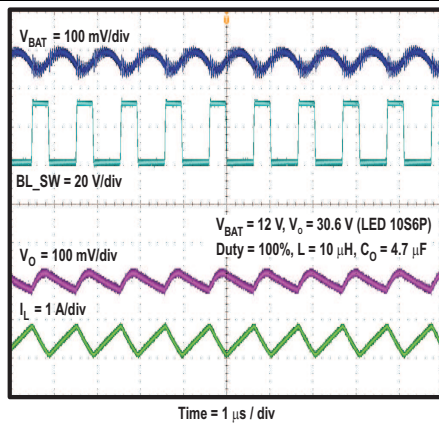
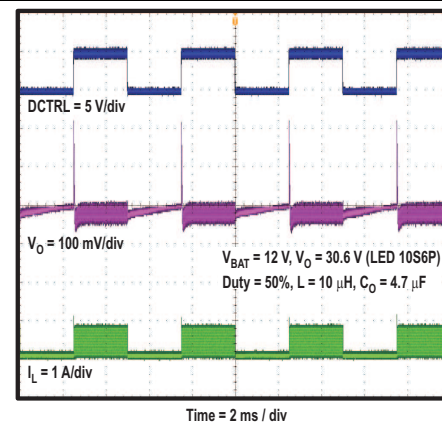
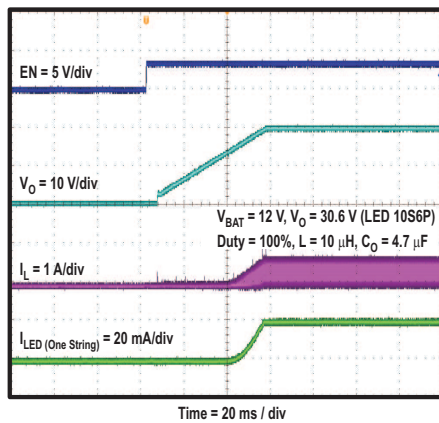
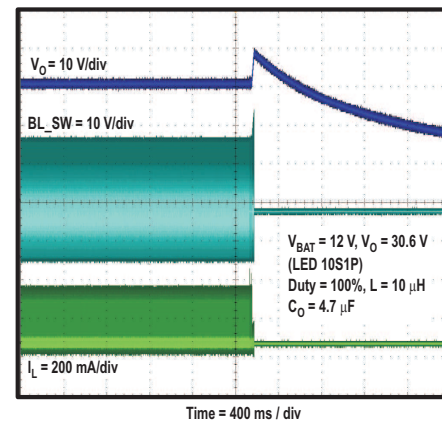
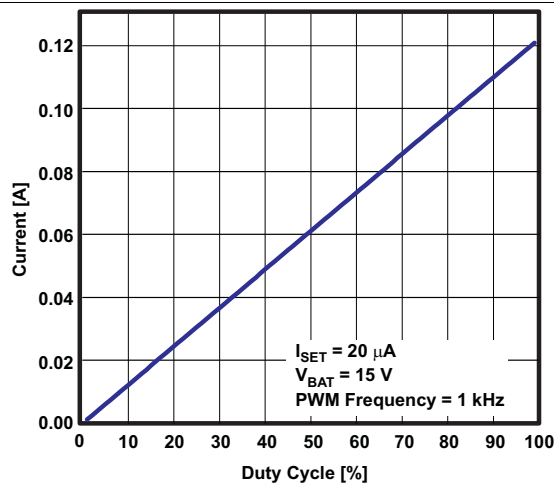
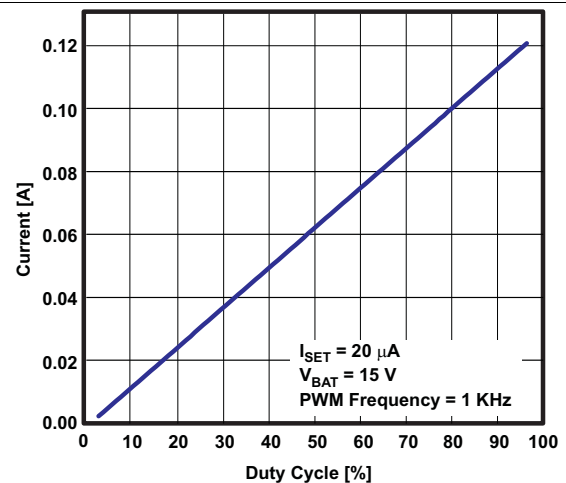


Figure 18. WLED Driver Efficiency vs Output Current

## Typical Characteristics (continued)


**Figure 19. WLED Driver Switching Waveforms**

**Figure 20. WLED Driver Output Ripple at PWM Dimming**

**Figure 21. WLED Driver Power-On Sequence**

**Figure 22. WLED Driver Open WLED Protection**

**Figure 23. WLED Driver PWM Dimming Linearity 100 Hz**

**Figure 24. WLED Driver PWM Dimming Linearity 1 kHz**





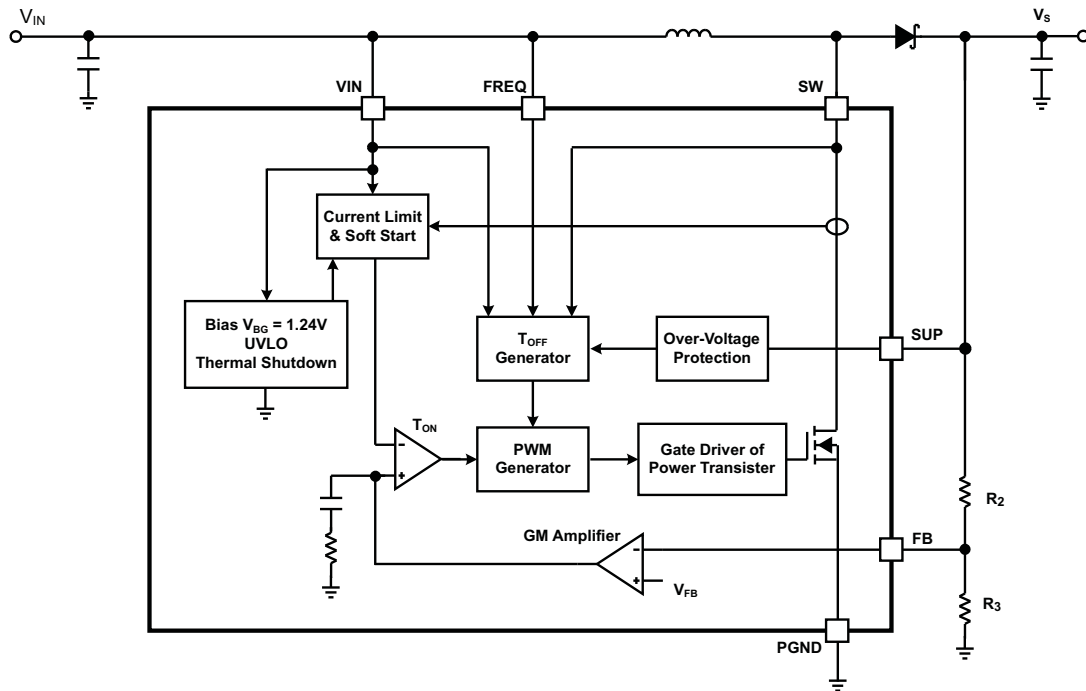
## 7.3 Feature Description

### 7.3.1 AVDD Boost Regulator

The AVDD boost regulator is designed for output voltages up to 16.5 V with a switch peak current limit of 1.8 A minimum. The device, which operates in a current-mode scheme with quasi-constant frequency, is internally compensated to minimize the pin and component counts. The switching frequency is selectable between 650 kHz and 1.2 MHz and the minimum input voltage is 2.3 V.

During the on-time, the current rises in the inductor. When the current reaches a threshold value set by the internal GM amplifier, the power transistor is turned off. The polarity of the inductor voltage changes and forward biases the Schottky diode, which lets the current flow towards the output of the boost regulator. The off-time is fixed for a certain input voltage  $V_{IN}$  and output voltage  $V_S$ , and therefore maintains the same frequency when varying these parameters. However, for different output loads, the frequency changes slightly due to the voltage drop across the  $r_{DS(on)}$  of the power transistor which will have an effect on the voltage across the inductor and thus on  $t_{ON}$  ( $t_{OFF}$  remains fixed).

The fixed off-time maintains a quasi-fixed frequency that provides better stability for the system over a wide range of input and output voltages than conventional boost converters. The TPS65142 topology has also the benefits of providing very good load and line regulations, and excellent line and load transient responses.



**Figure 25. Boost Converter Block Diagram**

#### 7.3.1.1 Setting the Output Voltage

The output voltage is set by an external resistor divider. Typically, a minimum current of 50  $\mu$ A flowing through the feedback divider is enough to cover the noise fluctuation. If 70  $\mu$ A is chosen for higher noise immunity, the resistors shown in Figure 25 are then calculated as:

$$R_3 = \frac{V_{FB}}{70 \mu A} \approx 18.2 \text{ k}\Omega \quad R_2 = R_3 \times \left( \frac{V_S}{V_{FB}} - 1 \right) \quad (1)$$

where  $V_{FB} = 1.240 \text{ V}$

#### 7.3.1.2 Soft-Start (AVDD Boost Converter)

The AVDD boost converter has an internal digital soft-start to prevent high inrush current during start-up. The typical soft-start time is 2 ms.



## Feature Description (continued)

### 7.3.3 Negative Charge Pump

Figure 27 shows the block diagram of the negative charge pump. The negative charge pump needs to generate a voltage of  $-6\text{ V}$  to  $-7\text{ V}$  with a negative inverter or  $-12\text{ V}$  to  $-13\text{ V}$  with a negative doubler. The reference voltage from the REF pin is  $3.15\text{ V}$ . The bias to the REF block comes from the SUP pin. The error amplifier is referenced to the ground. The  $V_{GL}$  can be set with the following equation:

$$V_{GL} = -\frac{R_4}{R_5} \times V_{REF} \quad (3)$$

where  $V_{REF} = 3.12\text{ V}$

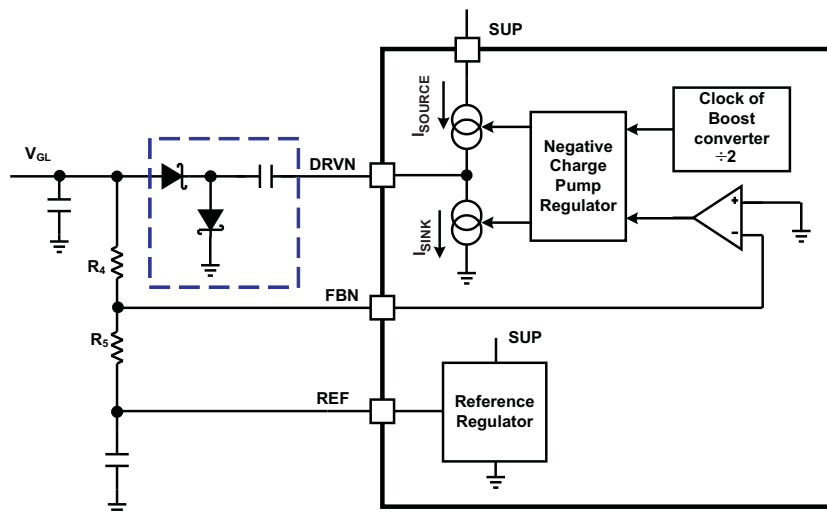


Figure 27. Block Diagram of the Negative Charge Pump Regulator with a Negative Inverter Configuration

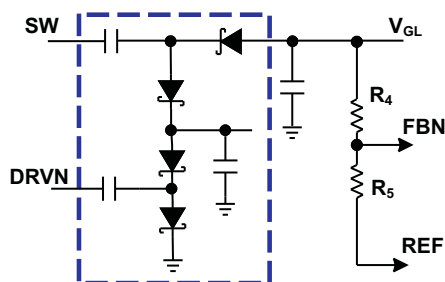


Figure 28. Negative Doubler Configuration for the Negative Charge Pump Regulator

### 7.3.4 Gate Voltage Shaping

The VGHM output is controlled by the VFLK logic input and the VDPM voltage level.

The VDPM pin allows the user to set a delay before the Gate Voltage Shaping starts. The voltage of the VDPM pin is zero volt at power on. When the output voltage of the AVDD boost converter rises above a power-good threshold, a power-good signal enables a  $20\text{-}\mu\text{A}$  current source that charges the capacitor connected between the VDPM pin and the ground. When the VDPM-pin voltage rises to  $1.24\text{ V}$ , the Gate Voltage Shaping is enabled.

The VFLK input controls the M1 and the M2 transistors, as shown in Figure 29, after the Gate Voltage Shaping is enabled:

When VFLK = "low", M1 is turned on so VGHM is connected to the VGH input.



## Feature Description (continued)

When VFLK = “high”, M2 is turned on so VGHM voltage is discharged through M2 and the resistor connected to the RE pin.

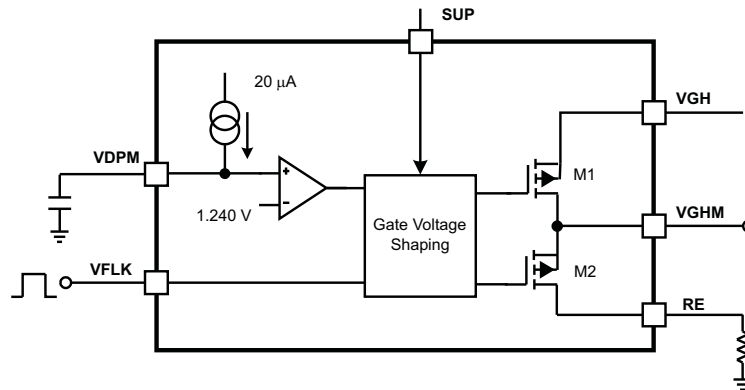


Figure 29. Block Diagram of the Gate Voltage Shaping Function

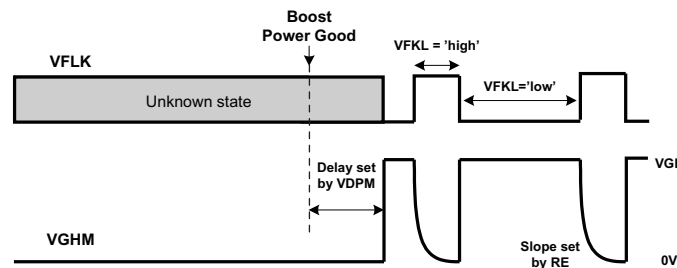


Figure 30. Gate Voltage Shaping Timing

### 7.3.5 VCOM Buffer

The VCOM Buffer power supply pin is the SUP pin connected to the AVDD boost converter  $V_S$ . To achieve good performance and minimize the output noise, a 1- $\mu$ F ceramic bypass capacitor is required directly from the SUP pin to ground. The buffer is not designed to drive high capacitive loads; therefore, it is recommended to connect a series resistor at the output to provide stable operation when driving a high capacitive load. With a 3.3- $\Omega$  series resistor, a capacitive load of 10 nF can be driven, which is usually sufficient for typical LCD applications.

### 7.3.6 Reset

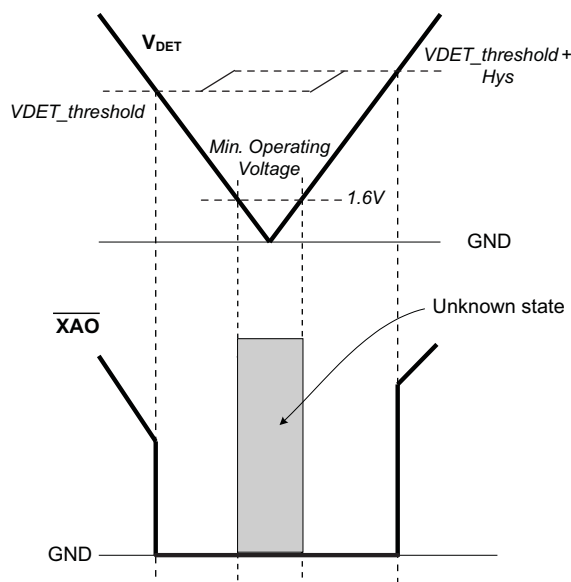
The device has an integrated reset function with an open-drain output capable of sinking 1 mA. The reset function monitors the voltage applied to its sense input  $V_{(DET)}$ . As soon as the voltage on  $V_{(DET)}$  falls below the threshold voltage,  $V_{(DET)}$ , of typically 1.1 V, the reset function asserts its reset signal by pulling  $\overline{XAO}$  low. Typically, a minimum current of 50  $\mu$ A flowing through the feedback divider is enough to cover the noise fluctuation. Therefore, to select  $R_{12}$  and  $R_{13}$  (see Figure 33), one has to set the input voltage limit ( $V_{IN(LIM)}$ ) at which the reset function will pull  $\overline{XAO}$  to low state.  $V_{IN(LIM)}$  must be higher than the UVLO threshold. If 70  $\mu$ A is chosen,

$$R_{13} = \frac{V_{(DET)}}{70 \mu A} \approx 18.2 \text{ k}\Omega \quad R_{12} = R_{13} \times \left( \frac{V_{IN(LIM)}}{V_{(DET)}} - 1 \right) \quad (4)$$

where  $V_{DET} = 1.1 \text{ V}$ .

The  $\overline{XAO}$  output is also controlled by the UVLO function. When the input voltage is below the UVLO threshold,  $\overline{XAO}$  output is forced low until the input voltage is lower than 1.6 V. The  $\overline{XAO}$  output is in an unknown state when the input voltage is below the 1.6 V threshold.

## Feature Description (continued)



**Figure 31. Voltage Detection and  $\overline{\text{XAO}}$  Pin**

When the input voltage  $V_{IN}$  rises, once the voltage on VDET pin exceeds its threshold voltage plus the hysteresis, the  $\overline{\text{XAO}}$  signal will go high.

The reset function is operational for  $V_{IN} \geq 1.6 \text{ V}$ .

The reset function is configured as a standard open-drain and requires a pull-up resistor. The resistor  $R_{(\text{XAO})}$  ( $R_{14}$  in Figure 33), which must be connected between the  $\overline{\text{XAO}}$  pin output and a positive voltage  $V_X$  greater than 2 V – 'high' logic level can be chosen as follows:

$$R_{14} > \frac{V_X}{1 \text{ mA}} \quad \text{and} \quad R_{14} < \frac{V_X - 2 \text{ V}}{2 \mu\text{A}} \quad (5)$$

### 7.3.7 Under-voltage Lockout (UVLO)

The TPS65142 monitors both  $V_{IN}$  and  $V_{BAT}$  inputs for under-voltage lockout. When the  $V_{IN}$  input is under its UVLO threshold, the whole IC is disabled to avoid mis-operation. When the  $V_{IN}$  input rises above its UVLO threshold, all functions are enabled except the WLED driver. The WLED driver, including the WLED boost converter and the current sinks, will be enabled when the  $V_{BAT}$  input is also higher than its UVLO threshold.

### 7.3.8 Thermal Shutdown

A thermal shutdown is implemented to prevent damages because of excessive heat and power dissipation. Typically the thermal shutdown threshold for the junction temperature is 150°C. When the thermal shutdown is triggered the device stops switching until the junction temperature falls below typically 136°C. Then the device starts switching again.

### 7.3.9 WLED Boost Regulator

The WLED boost regulator is a current-mode PWM regulator with internal loop compensation. The internal compensation ensures a stable output over the full input and output voltage range. The WLED boost regulator switches at fixed 1 MHz. The output voltage of the boost regulator is automatically set by the TPS65142 to minimize the voltage drop across the current-sink IFBx pins. The lowest IFB-pin voltage to regulated to 400 mV. When the output voltage is too close to the input, the WLED boost regulator may not be able to regulate the output due to the limitation of the minimum duty cycle. In that case, the user needs to increase the number of WLED in series or to include series ballast resistors to provide enough headroom for the boost converter to operate. The WLED boost regulator cannot regulate its output to a voltage below 15 V.

## Feature Description (continued)

### 7.3.10 Current Sinks

The six current sink regulators can each provide a maximum of 25 mA. The IFB current must be programmed to the highest WLED current expected using an ISET-pin resistor with the following equation:

$$I_{(FB)} = K_{(ISET)} \frac{V_{(ISET)}}{R_{(ISET)}} \quad (6)$$

where

- $K_{(ISET)}$  = Current multiple (1000 typical)
- $V_{(ISET)}$  = ISET pin voltage (1.229 V typical)
- $R_{(ISET)}$  = ISET-pin resistor value

The TPS65142 has built-in precise current sink regulators. The current matching error among 6 current sinks is below 2.5%. This means the differential values between the maximum and minimum currents of the six current sinks divided by the average current of the six is less than 2.5%.

### 7.3.11 Unused IFB Pins

If the application requires less than 6 WLED strings, one can easily disable unused IFBx pins by simply leaving the unused IFB pin open or shorting it to ground. If the IFB pin is open, the boost output voltage ramps up to  $V_O$  overvoltage threshold during start up. The IC then detects the zero current string and removes it from the feedback loop. If the IFB pin is shorted to ground, the IC detects the short immediately after WLED driver is enable, and the boost output voltage does not go up to  $V_O$  overvoltage threshold. Instead, it ramps to the regulation voltage after the soft start.

### 7.3.12 PWM Dimming

The WLED brightness is controlled by the PWM signal on the DCTRL pin. The frequency and duty cycle of the DCTRL signal is replicated on the IFB pin current. Keep the dimming frequency in the range of 100 Hz to 1 kHz to avoid screen flickering and to maintain dimming linearity. Screen flickering may occur if the dimming frequency is below the range. The minimum achievable duty cycle increases with the dimming frequency. For example, while a 0.1% dimming duty cycle, giving a 1000:1 dimming range, is achievable at 100 Hz dimming frequency, only 1% duty cycle, giving a 100:1 dimming range, is achievable with a 1-kHz dimming frequency, and 5% dimming duty cycle is achievable with 5 kHz dimming frequency. The device can work at high dimming frequency such as 20 kHz, but then only 15% duty cycle can be achieved. The TPS65142 is designed to minimize the AC ripple on the output capacitor during PWM dimming. Careful passive component selection is also critical to minimize AC ripple on the output capacitor.

### 7.3.13 Enabling the WLED Driver

The WLED driver (including the WLED boost converter and the six current sinks) is enabled when all following four conditions are satisfied:

1. the VBAT input voltage is higher than its under-voltage-lockout (UVLO) threshold;
2. the REF regulator output is higher than its power-good threshold;
3. the output voltage  $V_O$  is within 2 V of the input voltage  $V_{BAT}$ ;
4. and the enable input from the EN pin is high.

Pulling the EN pin low shuts down the WLED driver.

### 7.3.14 Soft-Start of WLED Boost Regulator

Once the above four conditions are satisfied, the WLED boost converter begins the internal soft-start. The soft-start function gradually ramps up the reference voltage of the error amplifier to prevent the output-voltage over shoot and inrush current from the VBAT input.

### 7.3.15 Protection of WLED Driver

The TPS65142 has multiple protection mechanisms to secure the safe operation of the WLED driver.

## Feature Description (continued)

### 7.3.15.1 Current Limit Protection

The WLED boost regulator switching MOSFET has a pulse-by-pulse over-current limit of 1.5 A (minimum value). The PWM switch turns off when the inductor current reaches this current threshold and remains off until the beginning of the next switching cycle. This protects the device and external components under over-load conditions. When there is sustained overcurrent condition for more than 16 ms (under 100% dimming duty cycle), the IC turns off and requires VBAT POR or the EN pin toggling to restart.

Under severe over load and/or short-circuit conditions, the VO pin can be pulled below the input (VBAT pin voltage). Under this condition, the current can flow directly from the input to the output through the inductor and the Schottky diode. Turning off the PWM switch alone does not limit current anymore. In this case, the TPS65142 relies on the fuse at the input to protect the whole system. When the TPS65142 detects the output voltage to be 1 V (short-circuit detection threshold) below the input voltage, it shuts down the WLED driver. The IC restarts after input power-on reset (VBAT POR) or EN pin logic toggling.

### 7.3.15.2 Open WLED String Protection

If one of the WLED strings is open, the boost output rises to its over-voltage threshold (39 V typically). The IC detects the open WLED string by sensing no current in the corresponding IFBx pin. As a result, the IC removes the open IFBx pin from the voltage feedback loop. The output voltage drops and is regulated to the voltage for the remaining connected WLED strings. The IFBx current of the connected WLED string remains in regulation during the whole transition.

The IC shuts down if it detects that all of the WLED strings are open.

### 7.3.15.3 Overvoltage Protection

If the overvoltage threshold is reached, but the current sensed on the IFBx pin is below the regulation target, the IC regulates the boost output at the overvoltage threshold. This operation could occur when the WLED is turned on under cold temperature, and the forward voltages of the WLEDs exceed the over-voltage threshold. Maintaining the WLED current allows the WLED to warm up and their forward voltages to drop below the overvoltage threshold.

If any IFBx pin voltage exceeds IFB overvoltage threshold (17 V typical), the IC turns off the corresponding current sink and removes this IFB pin from VO regulation loop. The remaining IFBx pins' current regulation is not affected. This condition often occurs when there are several shorted WLEDs in one string. WLED mismatch typically does not create such large voltage difference among WLED strings.

### 7.3.16 Power Up/Down Sequence

The power up and power down sequences are shown in [Figure 32](#).

The operation of the bias converters are gated by the UVLO of the VIN voltage. The start-up of the WLED boost converter is gated by the UVLO of the VBAT input, the power good of the REF output, the (VBAT – 2 V) and VO comparator output, and the EN input. The REF output is powered by the output of the AVDD boost converter through the SUP pin; and hence, the WLED boost converter will not start before the AVDD boost converter.

#### 7.3.16.1 Power Up Sequence

The power up sequence of the bias portion is as following. When the VIN rises above the ULVO threshold, and the internal device enable signal is asserted. The AVDD boost converter begins the soft-start, the REF regulator starts to rise, the VCOM buffer is enabled, and both charge pumps begins to operate. When the REF output reaches its regulation voltage, a VREF power good signal is asserted for the WLED section. The AVDD boost converter continues the soft start until its output voltage reaches the AVDD power good threshold when an AVDD power good signal is asserted. The AVDD power good signal enables the 20-μA current to the VDPM pin to start the gate voltage shaping delay timer. The delay is programmed by the external capacitor connected to the VDPM pin and should be long enough to ensure that both charge pumps are ready before the delay ends. Once the delay ends, the gate voltage shaping (VGHM) output is enabled to be controlled by the VFLK input.

The power up sequence of the WLED driver section is as following. When the four conditions for the Enabling the WLED Driver section are satisfied, the WLED boost converter begins the soft start, together with the start of the current sinks. When any of the four conditions is not satisfied, the WLED boost converter will stop switching.

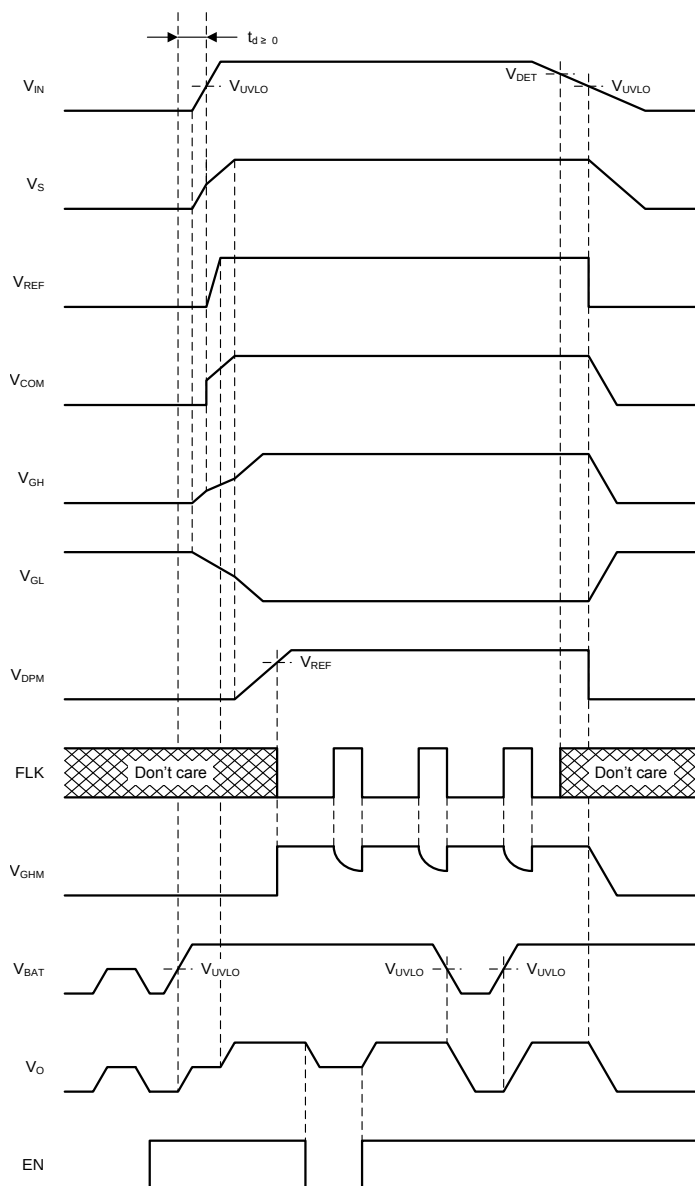
## Feature Description (continued)

To ensure proper start-up of the TPS65142 device, it is recommended to apply  $V_{BAT}$  before  $V_{IN}$  (see [Timing Requirements](#) and [Figure 32](#)).

### 7.3.16.2 Power Down Sequence and LCD Discharge Function

The power down sequence of the bias section is as following. When the input voltage  $V_{IN}$  falls below a predefined threshold set by  $V_{(DET\_THRESHOLD)}$ ,  $\overline{XAO}$  is driven low and the  $V_{GHM}$  output is driven to  $V_{GH}$ . (Note that when  $V_{IN}$  falls below the UVLO threshold, all IC functions are disabled except  $\overline{XAO}$  and  $V_{GHM}$  outputs). Since  $V_{GHM}$  is connected to  $V_{GH}$ , it tracks the output of the positive charge pump as it decays. This feature, together with  $\overline{XAO}$ , can be used to discharge the panel by turning on all the pixel TFTs and discharging them into the gradually decaying  $V_{GHM}$  voltage.  $V_{GHM}$  is held low during power-up.

The REF regulator will be disabled when  $V_{IN}$  falls below the UVLO threshold, hence, the WLED boost converter as well.



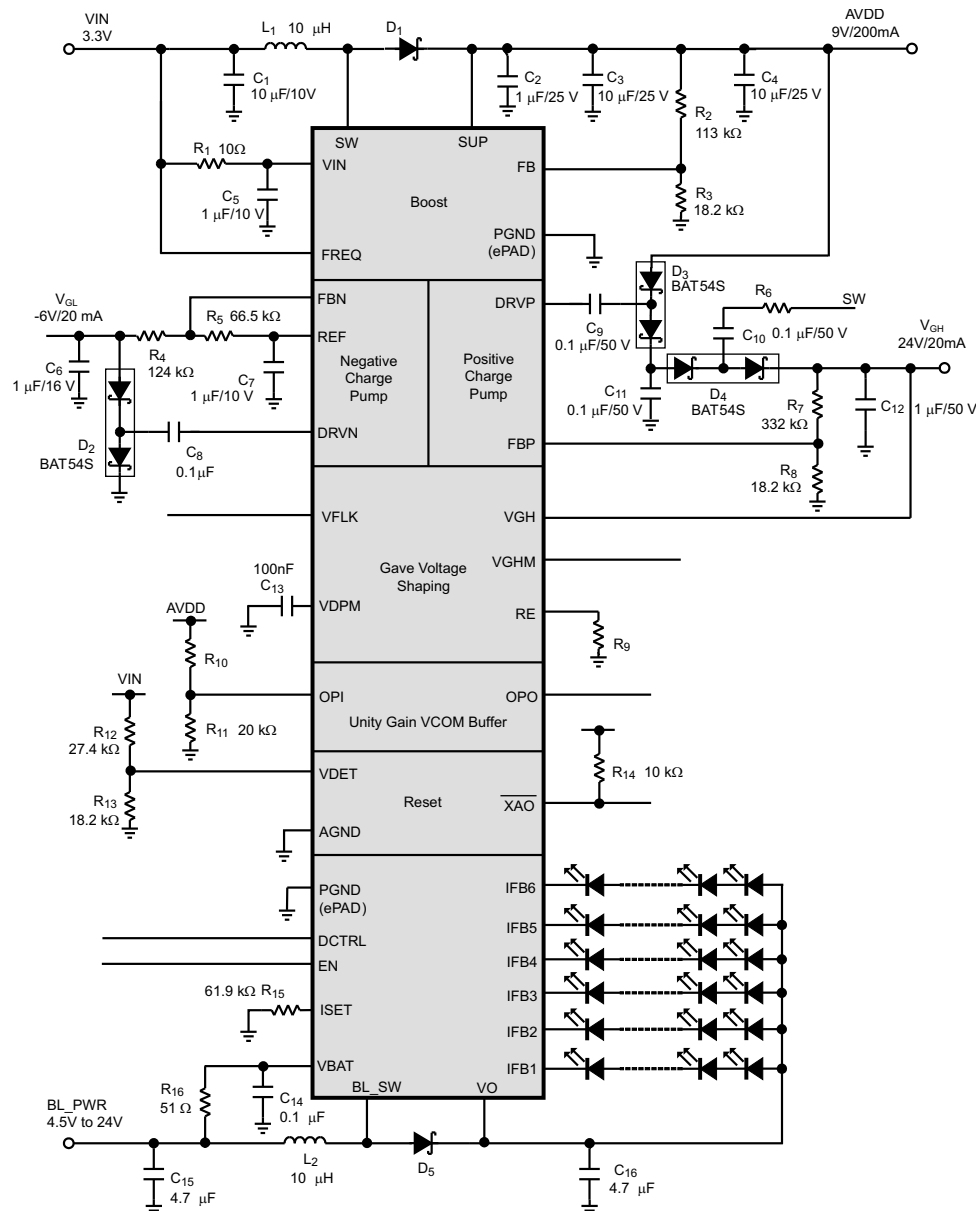
**Figure 32. Power Up/Down Sequence**

## 8 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. Customers should validate and test their design implementation to confirm system functionality.

### 8.1 Typical Application



**Figure 33. Typical Application Circuit**

## 9 Device and Documentation Support

### 9.1 Community Resources

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

**TI E2E™ Online Community** *TI's Engineer-to-Engineer (E2E) Community*. Created to foster collaboration among engineers. At [e2e.ti.com](http://e2e.ti.com), you can ask questions, share knowledge, explore ideas and help solve problems with fellow engineers.

**Design Support** *TI's Design Support* Quickly find helpful E2E forums along with design support tools and contact information for technical support.

### 9.2 Trademarks

E2E is a trademark of Texas Instruments.  
All other trademarks are the property of their respective owners.

### 9.3 Electrostatic Discharge Caution



These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

### 9.4 Glossary

[SLYZ022](#) — *TI Glossary*.

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



## 10 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<br>(1) | Material type<br>(2) | Package   Pins  | Package qty   Carrier | RoHS<br>(3) | Lead finish/<br>Ball material<br>(4) | MSL rating/<br>Peak reflow<br>(5) | Op temp (°C) | Part marking<br>(6) |
|------------------------------|---------------|----------------------|-----------------|-----------------------|-------------|--------------------------------------|-----------------------------------|--------------|---------------------|
| <a href="#">TPS65142RTGR</a> | Active        | Production           | WQFN (RTG)   32 | 3000   LARGE T&R      | Yes         | NIPDAU                               | Level-2-260C-1 YEAR               | -40 to 85    | TS65142             |
| TPS65142RTGR.B               | Active        | Production           | WQFN (RTG)   32 | 3000   LARGE T&R      | Yes         | NIPDAU                               | Level-2-260C-1 YEAR               | -40 to 85    | TS65142             |

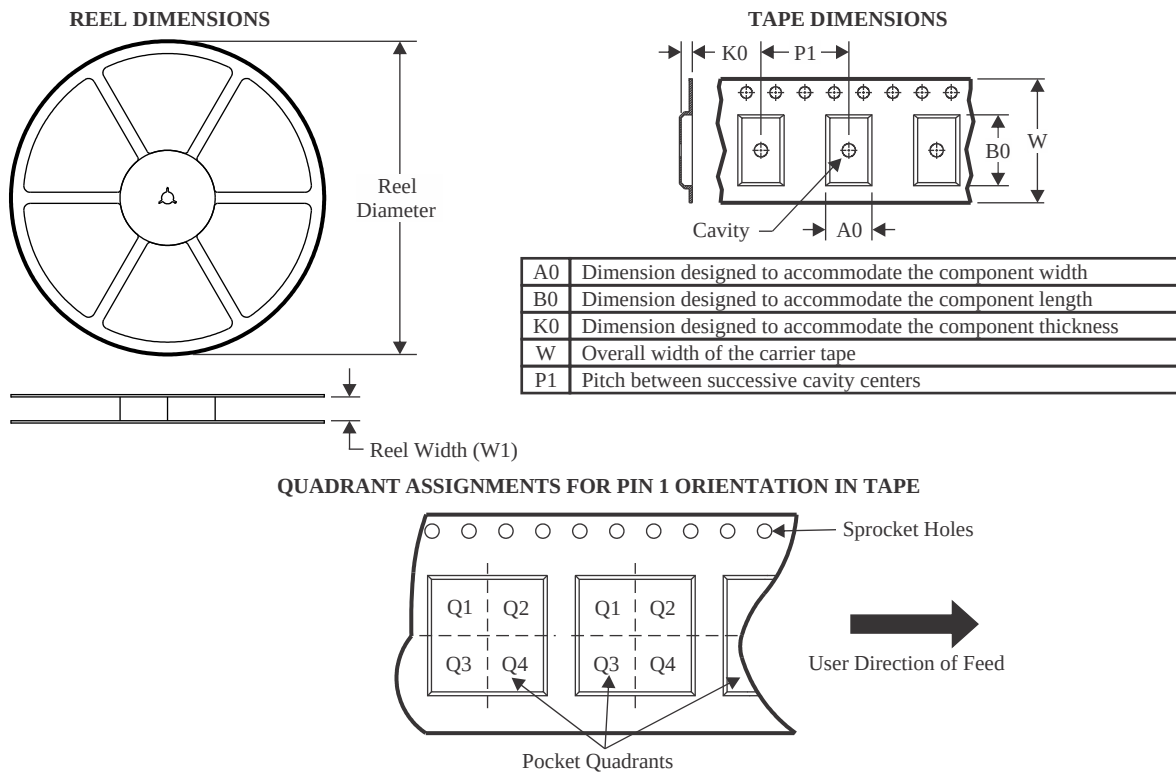
- <sup>(1)</sup> **Status:** For more details on status, see our [product life cycle](#).
- <sup>(2)</sup> **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.
- <sup>(3)</sup> **RoHS values:** Yes, No, RoHS Exempt. See the [TI RoHS Statement](#) for additional information and value definition.
- <sup>(4)</sup> **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.
- <sup>(5)</sup> **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.
- <sup>(6)</sup> **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

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

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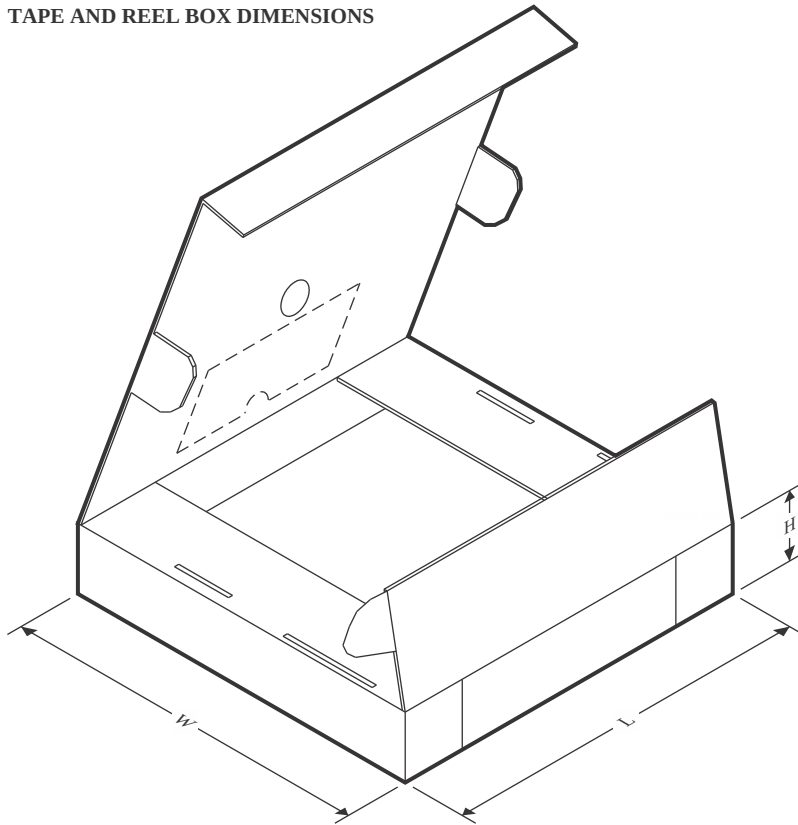
## TAPE AND REEL INFORMATION



\*All dimensions are nominal

| Device       | Package Type | Package Drawing | Pins | SPQ  | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|--------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| TPS65142RTGR | WQFN         | RTG             | 32   | 3000 | 330.0              | 16.4               | 3.3     | 6.3     | 1.0     | 8.0     | 16.0   | Q1            |

## TAPE AND REEL BOX DIMENSIONS



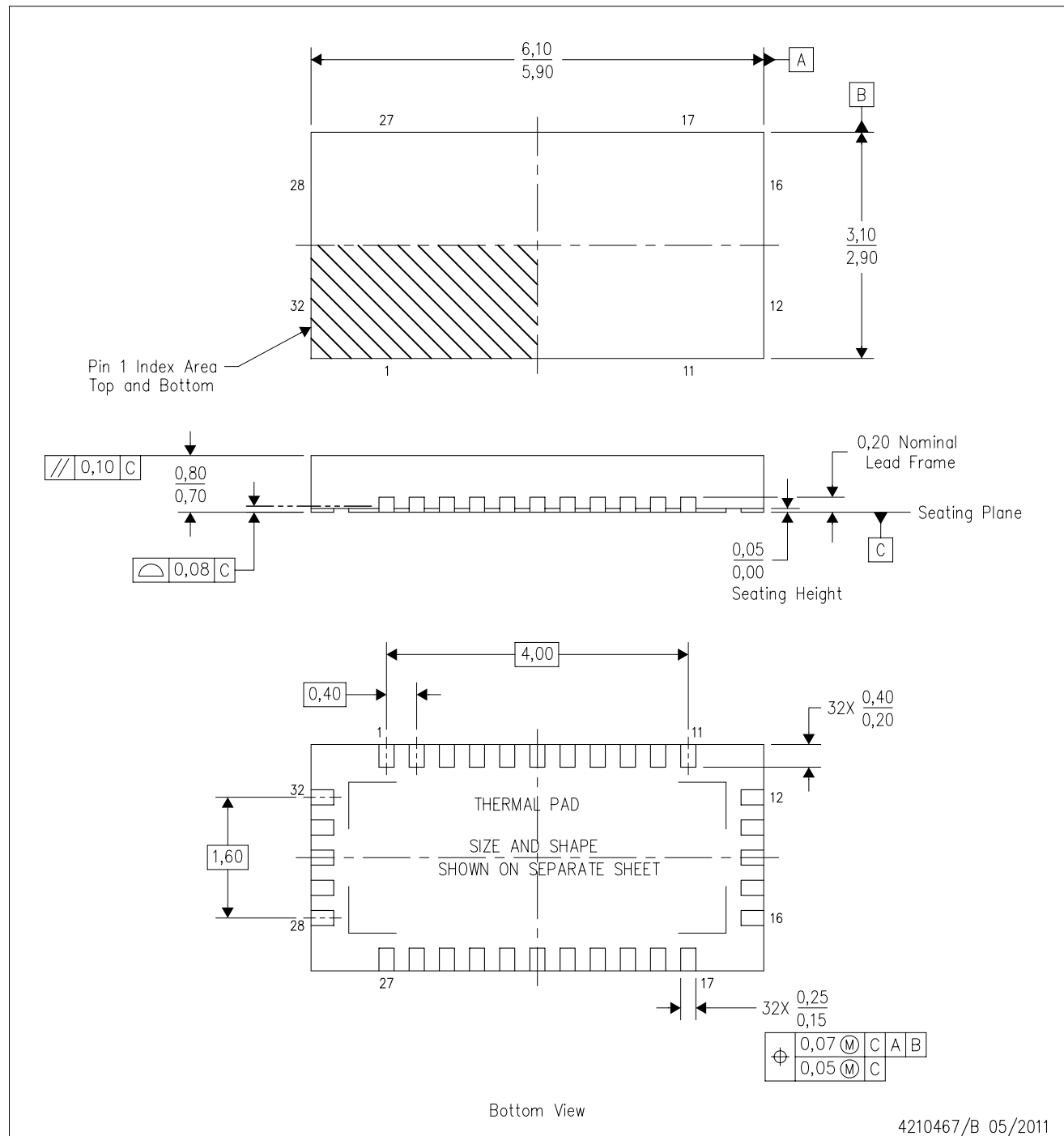
\*All dimensions are nominal

| Device       | Package Type | Package Drawing | Pins | SPQ  | Length (mm) | Width (mm) | Height (mm) |
|--------------|--------------|-----------------|------|------|-------------|------------|-------------|
| TPS65142RTGR | WQFN         | RTG             | 32   | 3000 | 353.0       | 353.0      | 32.0        |

# MECHANICAL DATA

RTG (R-PWQFN-N32)

PLASTIC QUAD FLATPACK NO-LEAD



- NOTES:
- All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.
  - This drawing is subject to change without notice.
  - QFN (Quad Flatpack No-Lead) package configuration.
  - The package thermal pad must be soldered to the board for thermal and mechanical performance.
  - See the additional figure in the Product Data Sheet for details regarding the exposed thermal pad features and dimensions.
  - Reference JEDEC MO-220.

## THERMAL PAD MECHANICAL DATA

RTG (R-PWQFN-N32)

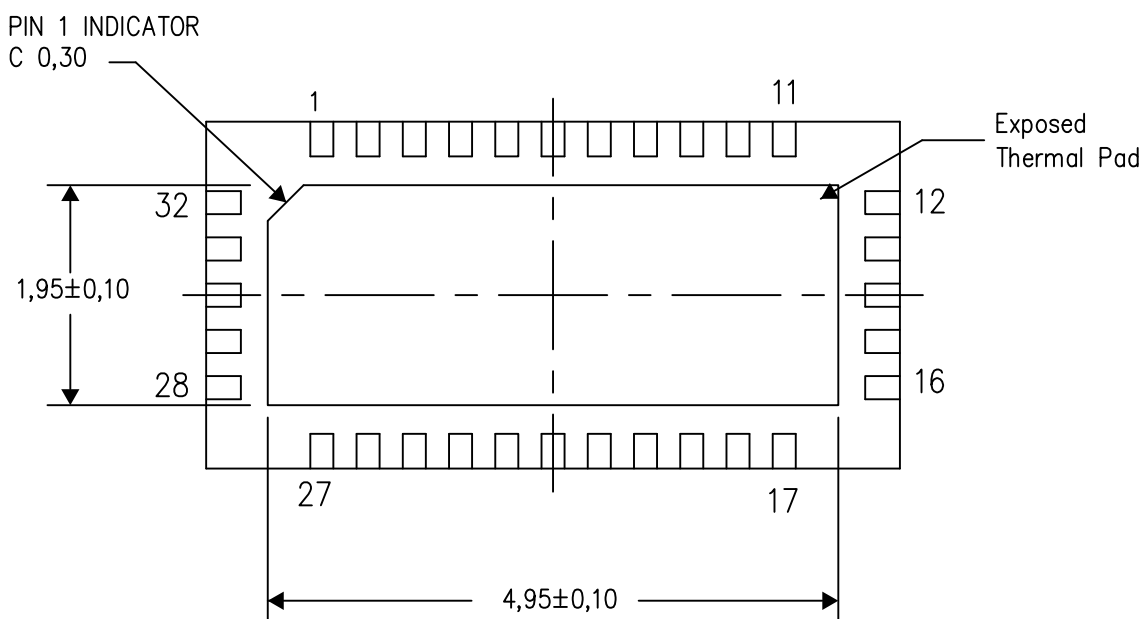
PLASTIC QUAD FLATPACK NO-LEAD

### THERMAL INFORMATION

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

For information on the Quad Flatpack No-Lead (QFN) package and its advantages, refer to Application Report, QFN/SON PCB Attachment, Texas Instruments Literature No. SLUA271. This document is available at [www.ti.com](http://www.ti.com).

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



Bottom View

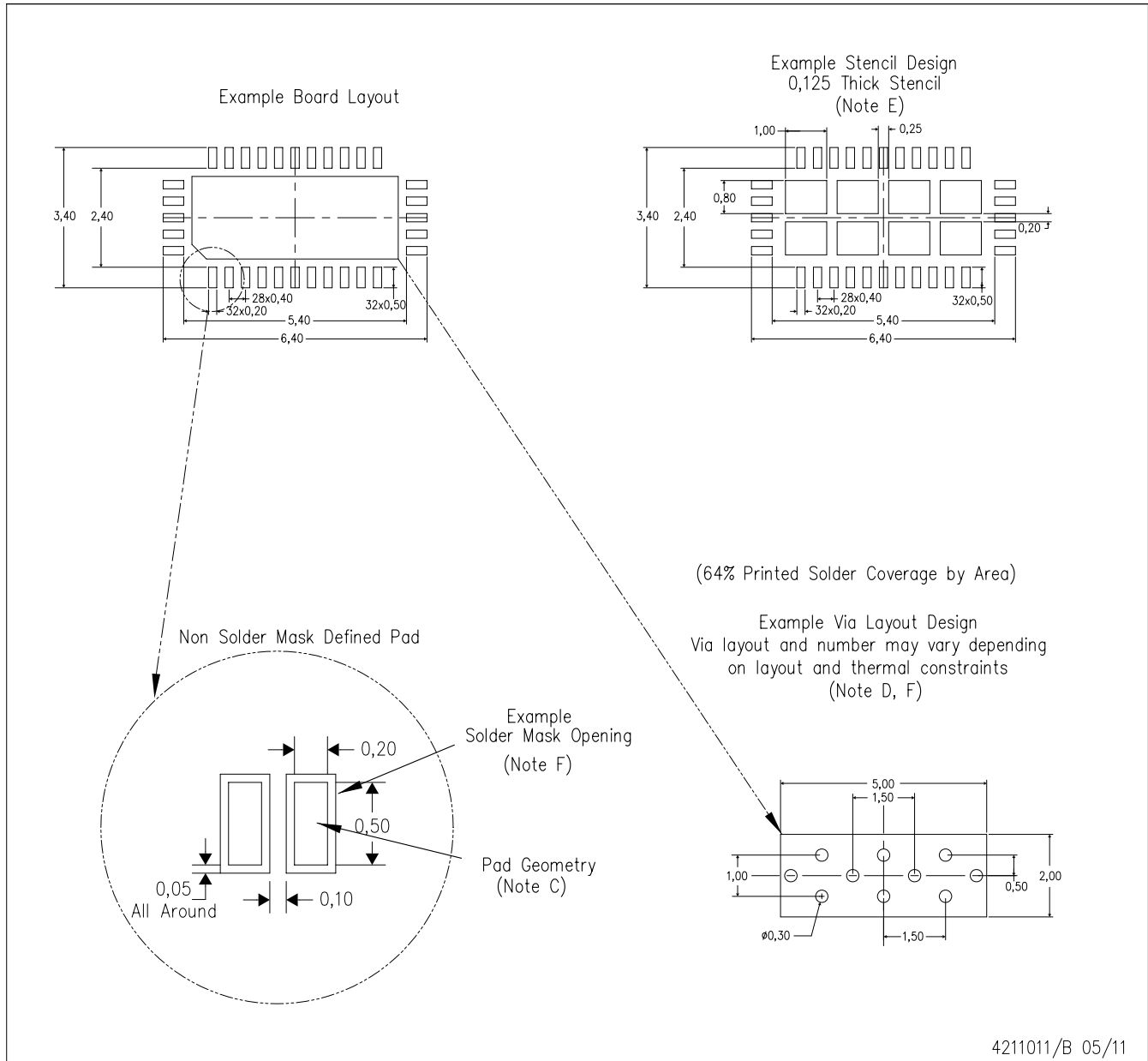
Exposed Thermal Pad Dimensions

4210534-2/D 12/13

NOTE: All linear dimensions are in millimeters

RTG (R-PWQFN-N32)

PLASTIC QUAD FLATPACK NO-LEAD



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



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