

# Programmable Output Voltage Ultra-Low Power Buck Converter with up to 50mA / 200 mA Output Current

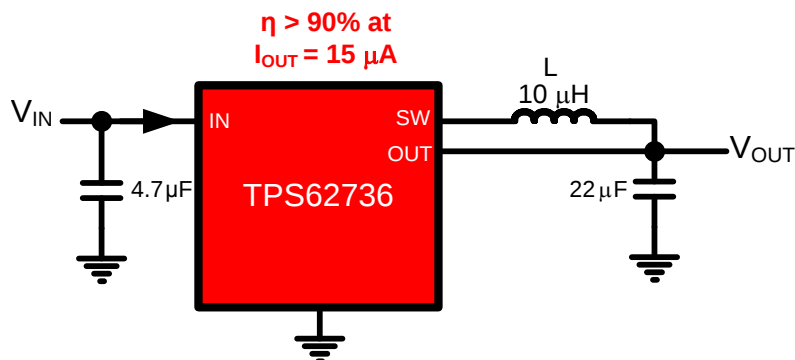
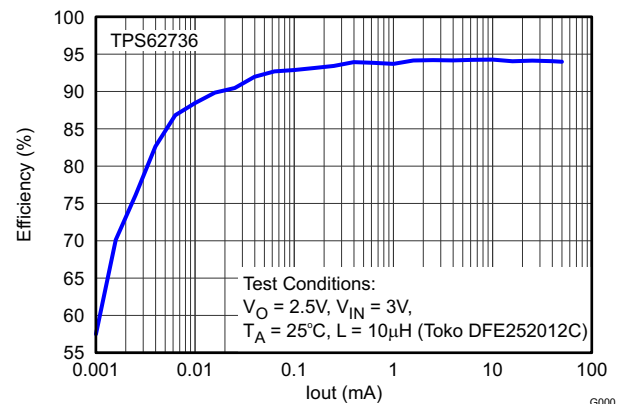
Check for Samples: [TPS62736](#), [TPS62737](#)

## FEATURES

- Industry's highest efficiency at low output currents: > 90% with  $I_{OUT} = 15 \mu A$
- Ultra-Low Power Buck Converter
  - TPS62736 Optimized for 50 mA Output Current
  - TPS62737 Optimized for 200mA Output Current
  - 1.3 V – 5 V Resistor Programmable Output Voltage Range
  - 2 V – 5.5 V Input Operating Range
  - 380 nA / 375 nA Quiescent Current During Active Operation for TPS62736 / TPS62737
  - 10 nA Quiescent Current During Ship Mode Operation
  - 2% Voltage Regulation Accuracy
- 100% Duty Cycle (Pass Mode)
- EN1 and EN2 Control
  - Two Power off states:
    - 1) Shipmode (full power off state)
    - 2) Standby mode includes VIN\_OK Indication
- Input Power Good Indication (VIN\_OK)
  - Push-pull Driver
  - Resistor Programmable Threshold Level

## APPLICATIONS

- Ultra Low Power Applications
- 2-Cell and 3-Cell Alkaline-Powered Applications
- Energy Harvesting
- Solar Charger
- Thermal Electric Generator (TEG) Harvesting
- Wireless Sensor Networks (WSN)
- Low Power Wireless Monitoring
- Environmental Monitoring
- Bridge and Structural Health Monitoring (SHM)
- Smart Building Controls
- Portable and Wearable Health Devices
- Entertainment System Remote Controls



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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.

## DESCRIPTION

The TPS6273X family provides a highly integrated ultra low power buck converter solution that is well suited for meeting the special needs of ultra low power applications such as energy harvesting. The TPS6273X provides the system with an externally programmable regulated supply in order to preserve the overall efficiency of the power management stage compared to a linear step down converter. This regulator is intended to step down the voltage from an energy storage element such as a battery or super capacitor in order to supply the rail to low voltage electronics. The regulated output has been optimized to provide high efficiency across low output currents (<10  $\mu$ A) to high currents (200 mA).

The TPS6273X integrates an optimized hysteretic controller for low power applications. The internal circuitry utilizes a time based sampling system in order to reduce the average quiescent current.

To further assist users in the strict management of their energy budgets, the TPS6273X toggles the input power good indicator to signal an attached microprocessor when the voltage on the input supply has dropped below a pre-set critical level. This signal is intended to trigger the reduction of load currents to prevent the system from entering an under-voltage condition. There are also independent enable signals to allow the system to control whether the converter is regulating the output, only monitoring the input voltage, or shut down in an ultra-low quiescent sleep state.

The input power good threshold and output regulator levels are programmed independently via external resistors.

All the capabilities of TPS6273X are packed into a small foot-print 14-lead 3.5mm x 3.5 mm QFN package (RGY).

## ORDERING INFORMATION

| T <sub>A</sub> | PART NO.                | OUTPUT VOLTAGE        | MAX OUTPUT CURRENT | INPUT UVLO | ORDERING NUMBER (TAPE AND REEL) | PACKAGE MARKING | QUANTITY |
|----------------|-------------------------|-----------------------|--------------------|------------|---------------------------------|-----------------|----------|
| –40°C to 85°C  | TPS62736 <sup>(1)</sup> | Resistor Programmable | 50 mA              | 2 V        | TPS62736RGYR                    | TPS62736        | 3000     |
|                |                         |                       |                    |            | TPS62736RGYT                    |                 | 250      |
| –20°C to 85°C  | TPS62737 <sup>(1)</sup> | Resistor Programmable | 200 mA             | 2V         | TPS62737RGYR                    | TPS62737        | 3000     |
|                |                         |                       |                    |            | TPS62737RGYT                    |                 | 250      |

(1) The RGY package is available in tape on reel. Add R suffix to order quantities of 3000 parts per reel, T suffix for 250 parts per reel.

## ABSOLUTE MAXIMUM RATINGS<sup>(1)</sup>

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

|                    |                             |                                                                                       | VALUE <sup>(2)</sup> |     | UNIT |
|--------------------|-----------------------------|---------------------------------------------------------------------------------------|----------------------|-----|------|
|                    |                             |                                                                                       | MIN                  | MAX |      |
| Pin voltage        |                             | Input voltage range on IN, EN1, EN2, VRDIV, VIN_OK_SET, VOUT_SET, VIN_OK, OUT, SW, NC | –0.3                 | 5.5 | V    |
| TPS62736           | Peak currents               | IN, OUT                                                                               |                      | 100 | mA   |
| TPS62737           | Peak currents               | IN, OUT                                                                               |                      | 370 | mA   |
| T <sub>J</sub>     | Temperature range           | Operating junction temperature range                                                  | –40                  | 125 | °C   |
| T <sub>STG</sub>   |                             | Storage temperature range                                                             | –65                  | 150 | °C   |
| ESD <sup>(3)</sup> | Human Body Model - (HBM)    |                                                                                       |                      | 1   | kV   |
|                    | Machine Model (MM)          |                                                                                       |                      | 150 | V    |
|                    | Charge Device Model - (CDM) |                                                                                       |                      | 500 | V    |

(1) Stresses beyond those listed under “absolute maximum ratings” may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other conditions beyond those indicated under “recommended operating conditions” is not implied. Exposure to absolute–maximum–rated conditions for extended periods may affect device reliability.

(2) All voltage values are with respect to VSS/ground terminal

(3) ESD testing is performed according to the respective JEDEC standard.

## THERMAL INFORMATION

| THERMAL METRIC <sup>(1)</sup> |                                              | RGY     | UNITS |
|-------------------------------|----------------------------------------------|---------|-------|
|                               |                                              | 14-Pins |       |
| $\theta_{JA}$                 | Junction-to-ambient thermal resistance       | 33.7    | °C/W  |
| $\theta_{JCTop}$              | Junction-to-case (top) thermal resistance    | 37.6    |       |
| $\theta_{JB}$                 | Junction-to-board thermal resistance         | 10.1    |       |
| $\Psi_{JT}$                   | Junction-to-top characterization parameter   | 0.4     |       |
| $\Psi_{JB}$                   | Junction-to-board characterization parameter | 10.3    |       |
| $\theta_{JCbott}$             | Junction-to-case (bottom) thermal resistance | 2.9     |       |

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

## RECOMMENDED OPERATING CONDITIONS

|                   |                                                 | MIN | NOM | MAX | UNIT       |
|-------------------|-------------------------------------------------|-----|-----|-----|------------|
| IN                | IN voltage range                                | 2   |     | 5.5 | V          |
| $C_{IN}$          | TPS62736 Input Capacitance                      | 4.7 |     |     | $\mu$ F    |
|                   | TPS62737 Input Capacitance                      | 22  |     |     |            |
| $C_{OUT}$         | Output Capacitance                              | 10  | 22  |     | $\mu$ F    |
| $R_1 + R_2 + R_3$ | Total Resistance for setting reference voltage  |     | 13  |     | M $\Omega$ |
| $L_{BUCK}$        | TPS62736 Inductance                             | 4.7 | 10  |     | $\mu$ H    |
|                   | TPS62737 Inductance                             | 10  |     |     |            |
| $T_A$             | TPS62736 Operating free air ambient temperature | –40 |     | 85  | °C         |
|                   | TPS62737 Operating free air ambient temperature | –20 |     | 85  |            |
| $T_J$             | Operating junction temperature                  | –40 |     | 105 | °C         |

## ELECTRICAL CHARACTERISTICS

Over recommended ambient temperature range, typical values are at  $T_A = 25^\circ\text{C}$ . Unless otherwise noted, specifications apply for conditions of  $V_{IN} = 4.2\text{ V}$ ,  $V_{OUT} = 1.8\text{ V}$  External components,  $C_{IN} = 4.7\text{ }\mu\text{F}$  for TPS62736 and  $22\text{ }\mu\text{F}$  for TPS62737,  $L_{BUCK} = 10\text{ }\mu\text{H}$ ,  $C_{OUT} = 22\text{ }\mu\text{F}$

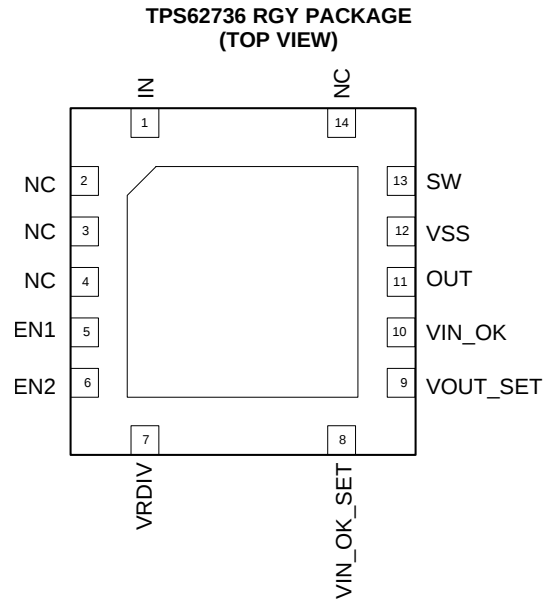
| PARAMETER                 |                                                               | TEST CONDITIONS                              | MIN | TYP | MAX | UNIT |
|---------------------------|---------------------------------------------------------------|----------------------------------------------|-----|-----|-----|------|
| <b>QUIESCENT CURRENTS</b> |                                                               |                                              |     |     |     |      |
| $I_Q$                     | TPS62736 Buck enabled state (EN1 = 0, EN2 = 1)                | $V_{IN} = 2\text{ V}$ , No load on $V_{OUT}$ |     | 380 | 550 | nA   |
|                           | TPS62736 Buck disabled VIN_OK active state (EN1 = 0, EN2 = 0) |                                              |     | 340 | 520 |      |
|                           | TPS62736 Ship mode state (EN1 = 1, EN2 = x)                   |                                              |     | 10  | 65  |      |
|                           | TPS62737 Buck enabled state (EN1 = 0, EN2 = 1)                |                                              |     | 375 | 600 | nA   |
|                           | TPS62737 Buck disabled VIN_OK active state (EN1 = 0, EN2 = 0) |                                              |     | 345 | 560 |      |
|                           | TPS62737 Ship mode state (EN1 = 1, EN2 = x)                   |                                              |     | 11  | 45  |      |

**ELECTRICAL CHARACTERISTICS (continued)**

Over recommended ambient temperature range, typical values are at  $T_A = 25^\circ\text{C}$ . Unless otherwise noted, specifications apply for conditions of  $V_{IN} = 4.2\text{ V}$ ,  $V_{OUT} = 1.8\text{ V}$  External components,  $C_{IN} = 4.7\text{ }\mu\text{F}$  for TPS62736 and  $22\text{ }\mu\text{F}$  for TPS62737,  $L_{BUCK} = 10\text{ }\mu\text{H}$ ,  $C_{OUT} = 22\text{ }\mu\text{F}$

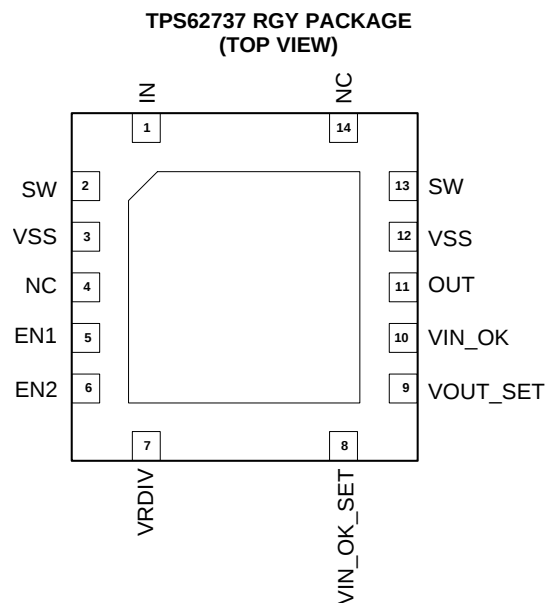
| PARAMETER               |                                                                                         | TEST CONDITIONS                                                                                          | MIN                   | TYP  | MAX                   | UNIT   |
|-------------------------|-----------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|-----------------------|------|-----------------------|--------|
| OUTPUT                  |                                                                                         |                                                                                                          |                       |      |                       |        |
| V <sub>BIAS</sub>       | Output regulation reference                                                             |                                                                                                          | 1.205                 | 1.21 | 1.217                 | V      |
| V <sub>OUT</sub>        | TPS62736 Output regulation ( <i>Spec does not include the resistor accuracy error</i> ) | I <sub>OUT</sub> = 10 mA;<br>1.3 V < V <sub>OUT</sub> < 3.3 V                                            | −2%                   | 0%   | 2%                    |        |
|                         | TPS62737 Output regulation ( <i>Spec does not include the resistor accuracy error</i> ) | I <sub>OUT</sub> = 100 mA;<br>1.3 V < V <sub>OUT</sub> < 3.3 V;                                          | −2%                   | 0%   | 2%                    |        |
|                         | TPS62736 Output line regulation                                                         | I <sub>OUT</sub> = 100 μA;<br>V <sub>IN</sub> = 2.4 V to 5.5 V                                           |                       | 0.01 |                       | % / V  |
|                         | TPS62737 Output line regulation                                                         | I <sub>OUT</sub> = 10 mA;<br>V <sub>IN</sub> = 2.3 V to 5.5 V                                            |                       | 0.31 |                       |        |
|                         | TPS62736 Output load regulation                                                         | I <sub>OUT</sub> = 100 μA to 50 mA,<br>V <sub>IN</sub> = 2.2 V                                           |                       | 0.01 |                       | % / mA |
|                         | TPS62737 Output load regulation                                                         | I <sub>OUT</sub> = 100 μA to 200 mA,<br>V <sub>IN</sub> = 2.2 V; -20 °C < T <sub>A</sub> < 85°C          |                       | 0.01 |                       | % / mA |
|                         | TPS62736 Output ripple                                                                  | V <sub>IN</sub> = 4.2V, I <sub>OUT</sub> = 1 mA,<br>C <sub>OUT</sub> = 22 μF                             |                       | 20   |                       | mVpp   |
|                         | TPS62737 Output ripple                                                                  | V <sub>IN</sub> = 4.2V, I <sub>OUT</sub> = 1 mA,<br>C <sub>OUT</sub> = 22 μF                             |                       | 40   |                       | mVpp   |
|                         | Programmable voltage range for output voltage threshold                                 | I <sub>OUT</sub> = 10 mA                                                                                 | 1.3                   |      | V <sub>IN</sub> - 0.2 | V      |
| V <sub>DO</sub>         | TPS62736 Drop-out-voltage when V <sub>IN</sub> is less than V <sub>OUT(SET)</sub>       | V <sub>IN</sub> = 2.1 V, V <sub>OUT(SET)</sub> = 2.5 V,<br>I <sub>OUT</sub> = 10 mA, 100% duty cycle     |                       | 24   | 30                    | mV     |
|                         | TPS62737 Drop-out-voltage when V <sub>IN</sub> is less than V <sub>OUT(SET)</sub>       | V <sub>IN</sub> = 2.1 V, V <sub>OUT(SET)</sub> = 2.5 V,<br>I <sub>OUT</sub> = 100 mA, 100% duty cycle    |                       | 180  | 220                   | mV     |
| t <sub>START-STBY</sub> | Startup time with EN1 low and EN2 transition to high (Standby Mode)                     | TPS62736, C <sub>OUT</sub> = 22 μF                                                                       |                       | 400  |                       | μs     |
|                         |                                                                                         | TPS62737, C <sub>OUT</sub> = 22 μF                                                                       |                       | 300  |                       | μs     |
| t <sub>START-SHIP</sub> | Startup time with EN2 high and EN1 transition from high to low (Ship Mode)              | C <sub>OUT</sub> = 22 μF                                                                                 |                       | 100  |                       | ms     |
| POWER SWITCH            |                                                                                         |                                                                                                          |                       |      |                       |        |
| R <sub>DS(on)</sub>     | TPS62736 High side switch ON resistance                                                 | V <sub>IN</sub> = 3 V                                                                                    |                       | 2.4  | 3                     | Ω      |
|                         | TPS62736 Low side switch ON resistance                                                  | V <sub>IN</sub> = 3 V                                                                                    |                       | 1.1  | 1.5                   | Ω      |
|                         | TPS62737 High side switch ON resistance                                                 | V <sub>IN</sub> = 2.1 V                                                                                  |                       | 1.8  | 2.2                   | Ω      |
|                         | TPS62737 Low side switch ON resistance                                                  | V <sub>IN</sub> = 2.1 V                                                                                  |                       | 0.9  | 1.3                   | Ω      |
| I <sub>LIM</sub>        | TPS62736 Cycle-by-cycle current limit                                                   | 2.4 V < V <sub>IN</sub> < 5.25 V;<br>1.3 V < V <sub>OUT</sub> < 3.3 V                                    | 68                    | 86   | 100                   | mA     |
|                         | TPS62737 Cycle-by-cycle current limit                                                   | 2.4 V < V <sub>IN</sub> < 5.25 V;<br>1.3 V < V <sub>OUT</sub> < 3.3 V;<br>-20 °C < T <sub>A</sub> < 85°C | 295                   | 340  | 370                   | mA     |
| f <sub>SW</sub>         | Max switching frequency                                                                 |                                                                                                          |                       | 2    |                       | MHz    |
| INPUT                   |                                                                                         |                                                                                                          |                       |      |                       |        |
| V <sub>IN-UVLO</sub>    | Input under voltage protection                                                          | V <sub>IN</sub> falling                                                                                  | 1.91                  | 1.95 | 2                     | V      |
| V <sub>IN-OK</sub>      | Input power good programmable voltage range                                             |                                                                                                          | 2                     |      | 5.5                   | V      |
| V <sub>IN-OK-ACC</sub>  | TPS62736 Accuracy of V <sub>IN-OK</sub> setting                                         | V <sub>IN</sub> increasing                                                                               | -2                    |      | 2                     | %      |
|                         | TPS62737 Accuracy of V <sub>IN-OK</sub> setting                                         |                                                                                                          | -3                    |      | 3                     |        |
| V <sub>IN-OK-HYS</sub>  | Fixed hysteresis on VIN_OK threshold, OK_HYST                                           | V <sub>IN</sub> increasing                                                                               |                       | 40   |                       | mV     |
| V <sub>IN_OK-OH</sub>   | V <sub>IN-OK</sub> output high threshold voltage                                        | Load = 10 μA                                                                                             | V <sub>IN</sub> - 0.2 |      |                       | V      |
| V <sub>IN_OK-OL</sub>   | V <sub>IN-OK</sub> output low threshold voltage                                         |                                                                                                          |                       |      | 0.1                   | V      |
| EN1 and EN2             |                                                                                         |                                                                                                          |                       |      |                       |        |
| V <sub>IH</sub>         | Voltage for EN High setting. Relative to V <sub>IN</sub>                                | V <sub>IN</sub> = 4.2V                                                                                   | V <sub>IN</sub> - 0.2 |      |                       | V      |
| V <sub>IL</sub>         | Voltage for EN Low setting.                                                             |                                                                                                          |                       |      | 0.2                   | V      |

## PIN ASSIGNMENTS



## PIN DESCRIPTION

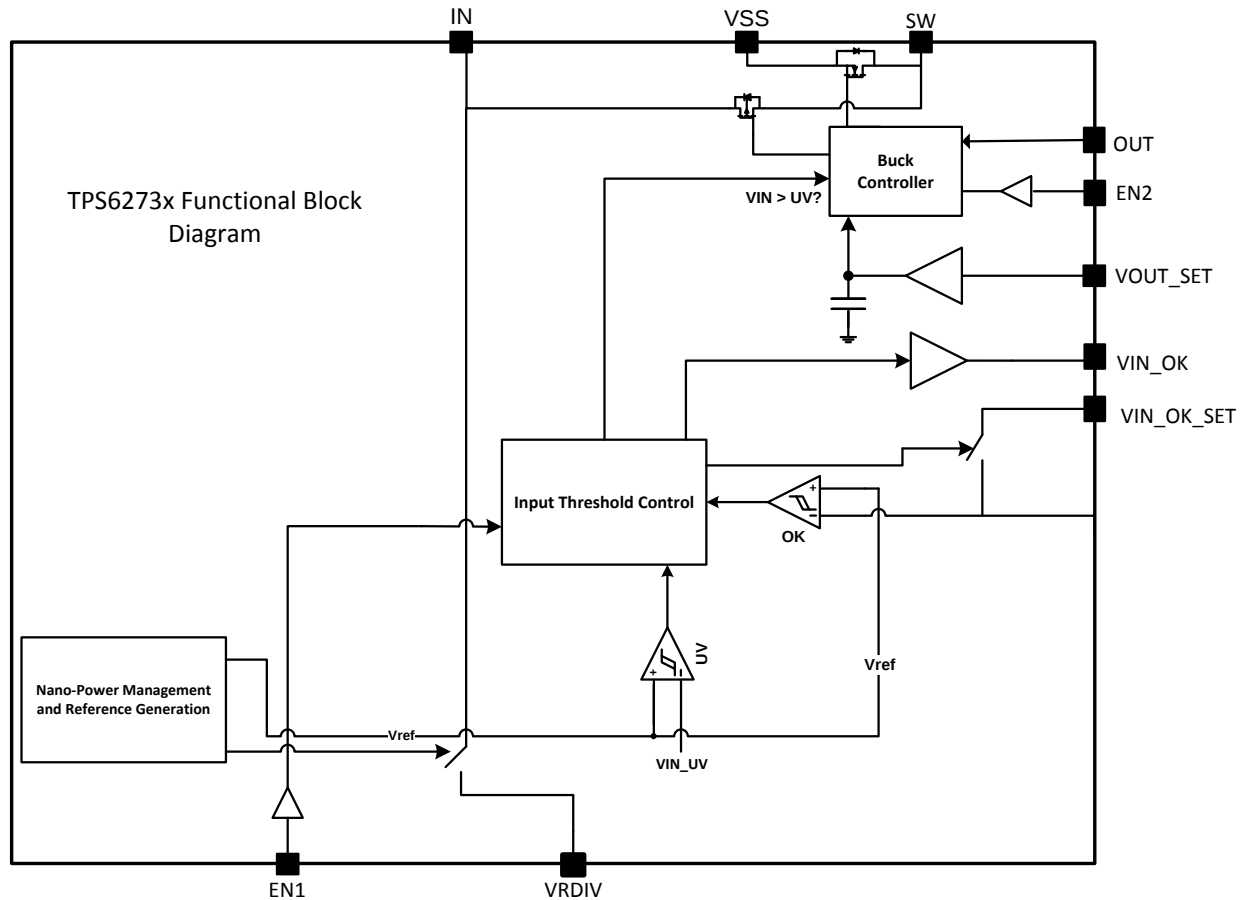
| PIN |             |          |                                                                                                                                                                                                                                                |
|-----|-------------|----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| NO. | NAME        | I/O Type | Description                                                                                                                                                                                                                                    |
| 1   | IN          | Input    | Input supply to the buck regulator                                                                                                                                                                                                             |
| 2   | NC          | Input    | Connect to VSS                                                                                                                                                                                                                                 |
| 3   | NC          | Input    | Connect to VSS                                                                                                                                                                                                                                 |
| 4   | NC          | Input    | Connect to VSS                                                                                                                                                                                                                                 |
| 5   | EN1         | Input    | Digital input for chip enable, standby, and ship-mode. EN1 = 1 sets ship mode independent of EN2. EN1=0, EN2 = 0 disables the buck converter and sets standby mode. EN1=0, EN2=1 enables the buck converter. Do not leave either pin floating. |
| 6   | EN2         | Input    |                                                                                                                                                                                                                                                |
| 7   | VRDIV       | Output   | Resistor divider biasing voltage                                                                                                                                                                                                               |
| 8   | VIN_OK_SET  | Input    | Resistor divider input for VIN_OK threshold. Pull to VIN to disable. Do not leave pin floating.                                                                                                                                                |
| 9   | VOUT_SET    | Input    | Resistor divider input for VOUT regulation level                                                                                                                                                                                               |
| 10  | VIN_OK      | Output   | Push-pull digital output for power good indicator for the input voltage. Pulled up to VIN pin.                                                                                                                                                 |
| 11  | OUT         | Output   | Step down (buck) regulator output                                                                                                                                                                                                              |
| 12  | VSS         | Input    | Ground connection for the device                                                                                                                                                                                                               |
| 13  | SW          | Input    | Inductor connection to switching node                                                                                                                                                                                                          |
| 14  | NC          | Input    | Connect to VSS                                                                                                                                                                                                                                 |
| 15  | Thermal Pad | Input    | Connect to VSS                                                                                                                                                                                                                                 |



### PIN DESCRIPTION

| PIN   |             |          |                                                                                                                                                                                                                                                |
|-------|-------------|----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| NO.   | NAME        | I/O Type | Description                                                                                                                                                                                                                                    |
| 1     | IN          | Input    | Input supply to the buck regulator                                                                                                                                                                                                             |
| 2, 13 | SW          | Input    | Inductor connection to switching node                                                                                                                                                                                                          |
| 3, 12 | VSS         | Input    | Ground connection for the device                                                                                                                                                                                                               |
| 4, 14 | NC          | Input    | Connect to VSS                                                                                                                                                                                                                                 |
| 5     | EN1         | Input    | Digital input for chip enable, standby, and ship-mode. EN1 = 1 sets ship mode independent of EN2. EN1=0, EN2 = 0 disables the buck converter and sets standby mode. EN1=0, EN2=1 enables the buck converter. Do not leave either pin floating. |
| 6     | EN2         | Input    |                                                                                                                                                                                                                                                |
| 7     | VRDIV       | Output   | Resistor divider biasing voltage                                                                                                                                                                                                               |
| 8     | VIN_OK_SET  | Input    | Resistor divider input for VIN_OK threshold. Pull to VIN to disable. Do not leave pin floating.                                                                                                                                                |
| 9     | VOUT_SET    | Input    | Resistor divider input for VOUT regulation level                                                                                                                                                                                               |
| 10    | VIN_OK      | Output   | Push-pull digital output for power good indicator for the input voltage. Pulled up to VIN pin.                                                                                                                                                 |
| 11    | OUT         | Output   | Step down (buck) regulator output                                                                                                                                                                                                              |
| 15    | Thermal Pad | Input    | Connect to VSS                                                                                                                                                                                                                                 |

## FUNCTIONAL BLOCK DIAGRAM



## TYPICAL APPLICATION SCHEMATIC

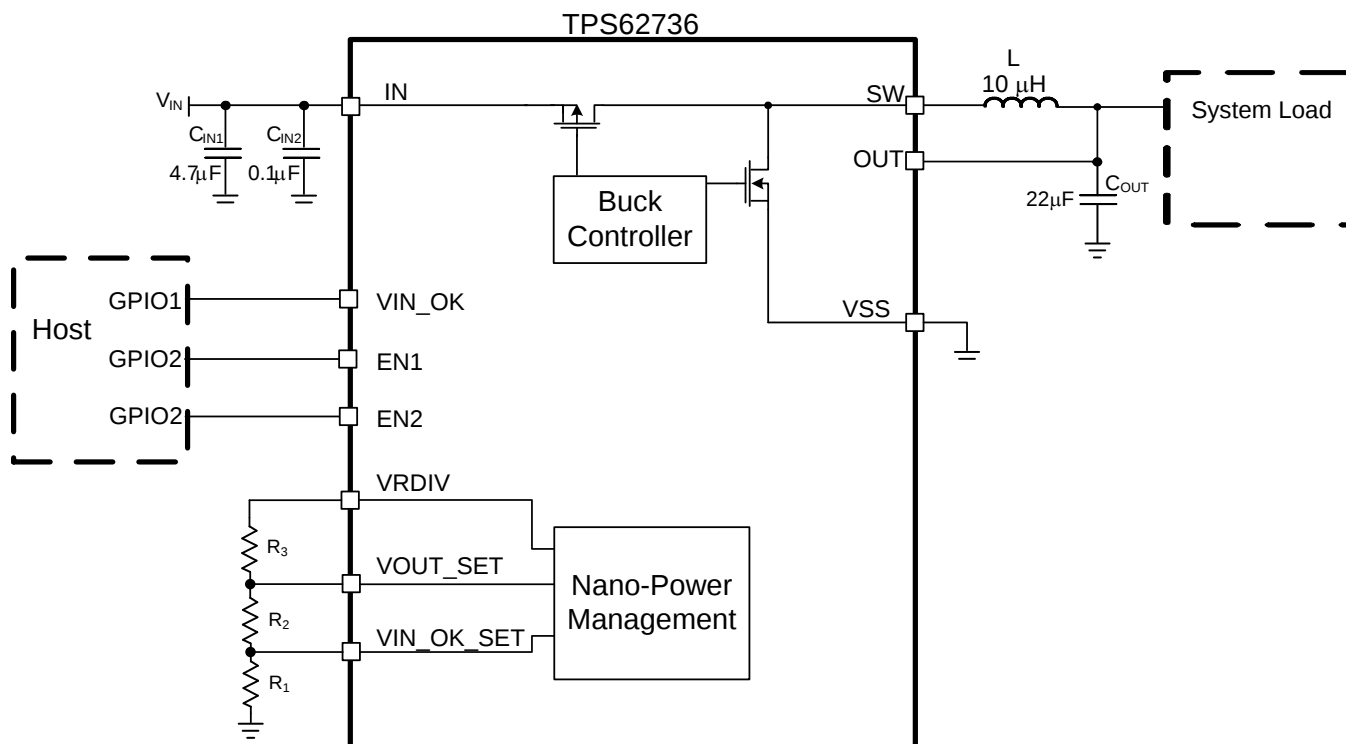


Figure 1. Typical Application Circuit for a 3-resistor String

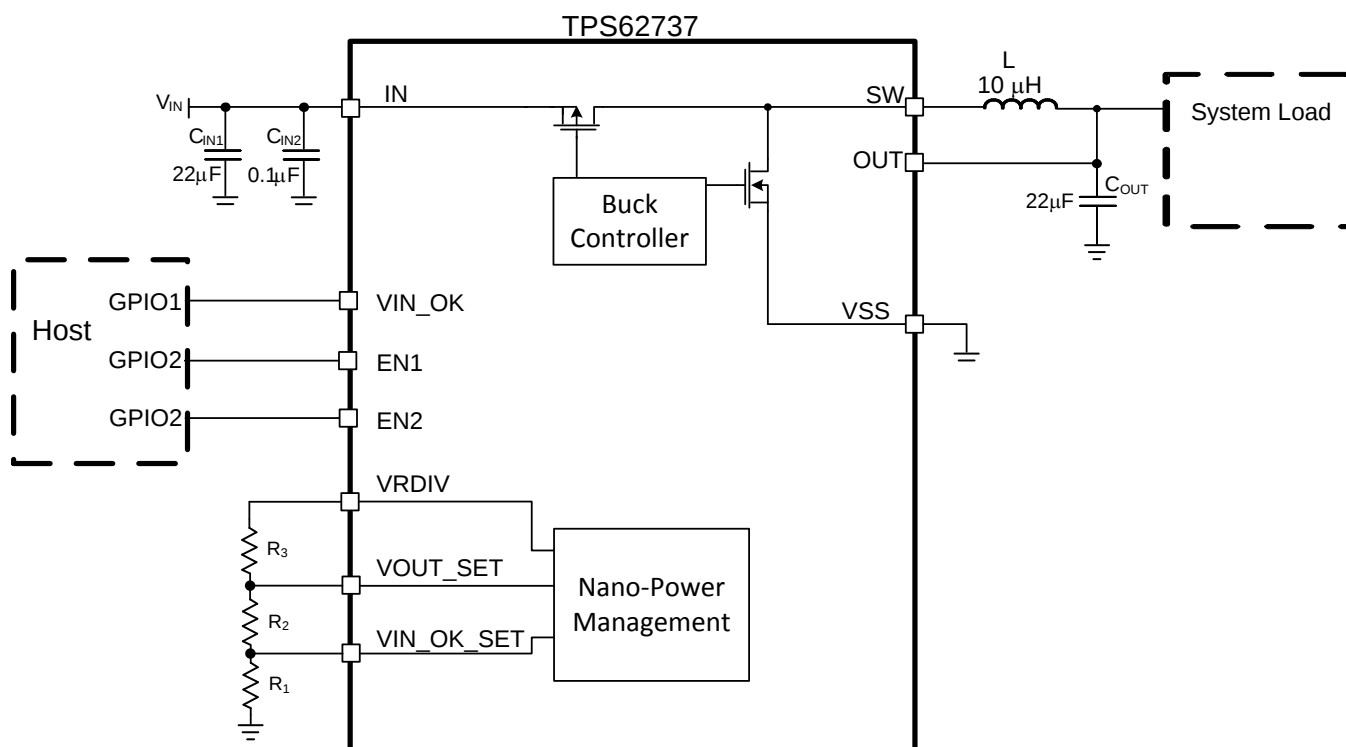


Figure 2. Typical Application Circuit

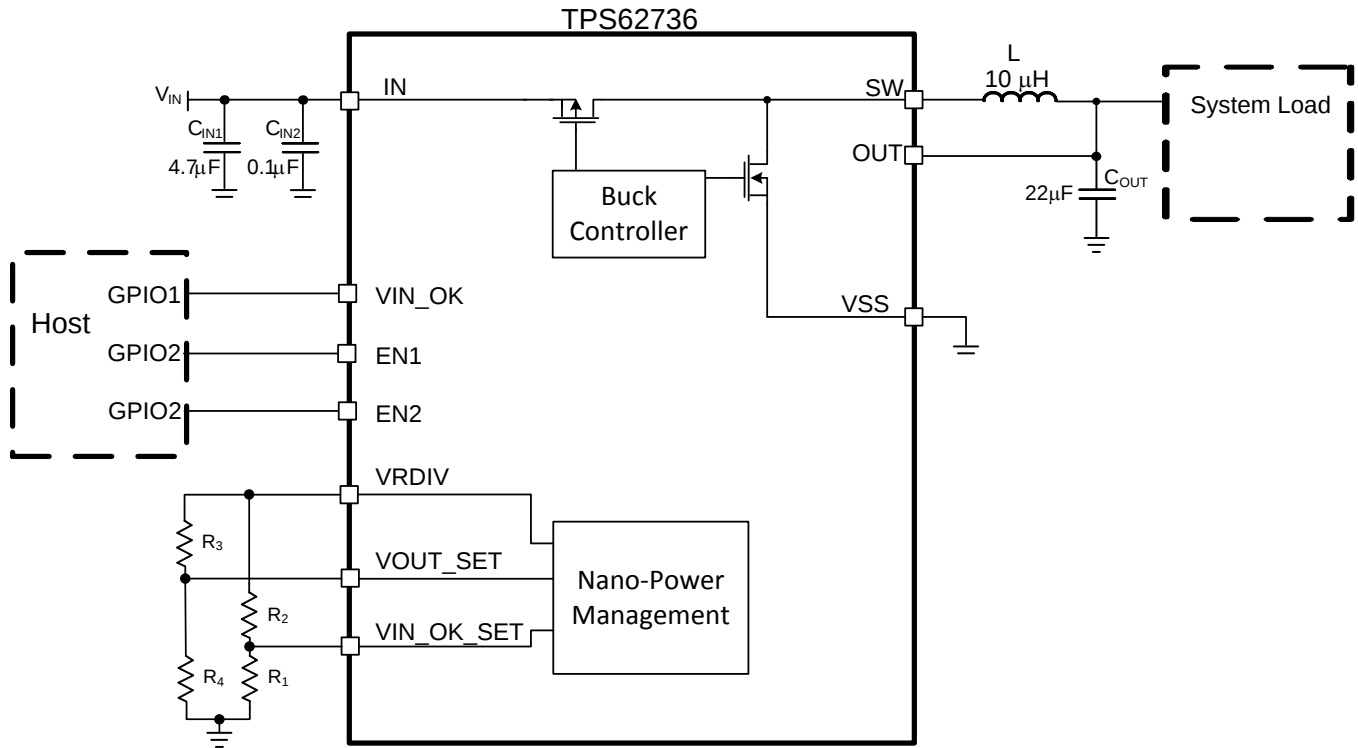


Figure 3. Typical Application Circuit for a 4-resistor String

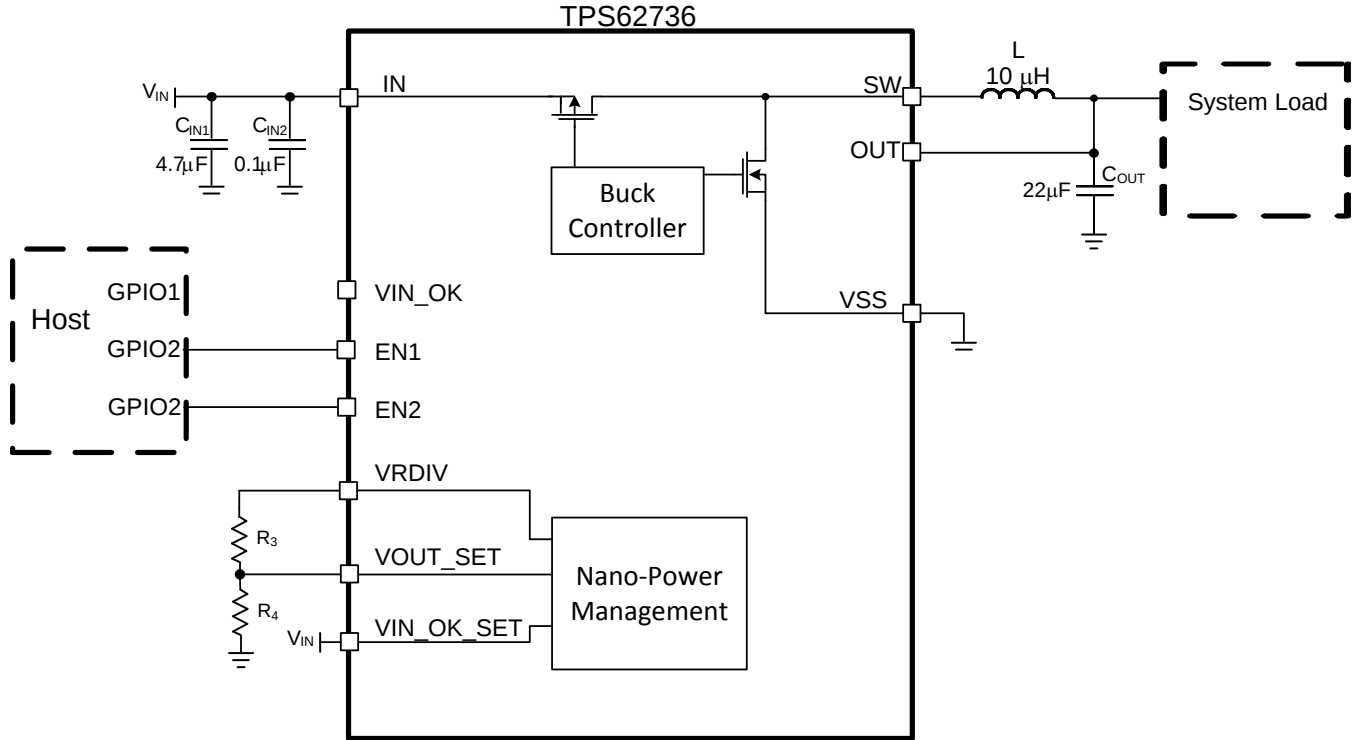


Figure 4. Typical Application Circuit for Disabling VIN\_OK

## TYPICAL CHARACTERISTICS

Table of Graphs for TPS62736

| Unless otherwise noted, graphs were taken using <a href="#">Figure 1</a> with L = Toko 10 $\mu$ H DFE252012C |                                                |                                                                                 | FIGURE                    |
|--------------------------------------------------------------------------------------------------------------|------------------------------------------------|---------------------------------------------------------------------------------|---------------------------|
| $\eta$                                                                                                       | $V_O = 2.5$ V Efficiency                       | vs. Output Current                                                              | <a href="#">Figure 5</a>  |
|                                                                                                              |                                                | vs. Input Voltage                                                               | <a href="#">Figure 6</a>  |
|                                                                                                              | $V_O = 1.8$ V Efficiency                       | vs. Output Current                                                              | <a href="#">Figure 7</a>  |
|                                                                                                              |                                                | vs. Input Voltage                                                               | <a href="#">Figure 8</a>  |
|                                                                                                              | $V_O = 1.3$ V Efficiency                       | vs. Output Current                                                              | <a href="#">Figure 9</a>  |
|                                                                                                              |                                                | vs. Input Voltage                                                               | <a href="#">Figure 10</a> |
| $V_{OUT}$ (DC)                                                                                               | $V_O = 2.5$ V                                  | vs. Output Current                                                              | <a href="#">Figure 11</a> |
|                                                                                                              |                                                | vs. Input Voltage                                                               | <a href="#">Figure 12</a> |
|                                                                                                              |                                                | vs. Temperature                                                                 | <a href="#">Figure 13</a> |
|                                                                                                              | $V_O = 1.8$ V                                  | vs. Output Current                                                              | <a href="#">Figure 14</a> |
|                                                                                                              |                                                | vs. Input Voltage                                                               | <a href="#">Figure 15</a> |
|                                                                                                              |                                                | vs. Temperature                                                                 | <a href="#">Figure 16</a> |
|                                                                                                              | $V_O = 1.3$ V                                  | vs. Output Current                                                              | <a href="#">Figure 17</a> |
|                                                                                                              |                                                | vs. Input Voltage                                                               | <a href="#">Figure 18</a> |
|                                                                                                              |                                                | vs. Temperature                                                                 | <a href="#">Figure 19</a> |
| $I_{OUT}$ MAX (DC)                                                                                           | $V_O = 2.5$ V                                  | vs. Input Voltage                                                               | <a href="#">Figure 20</a> |
|                                                                                                              | $V_O = 1.8$ V                                  |                                                                                 | <a href="#">Figure 21</a> |
|                                                                                                              | $V_O = 1.3$ V                                  |                                                                                 | <a href="#">Figure 22</a> |
| Input IQ                                                                                                     | EN1 = 1, EN2 = 0 (Ship Mode)                   | vs. Input Voltage                                                               | <a href="#">Figure 23</a> |
|                                                                                                              | EN1 = 0, EN2 = 0 (Standby Mode)                |                                                                                 | <a href="#">Figure 24</a> |
|                                                                                                              | EN1 = 0, EN2 = 1 (Active Mode)                 |                                                                                 | <a href="#">Figure 25</a> |
| Switching Frequency                                                                                          | $V_O = 2.5$ V                                  | vs. Output Current                                                              | <a href="#">Figure 27</a> |
|                                                                                                              |                                                | vs. Input Voltage                                                               | <a href="#">Figure 28</a> |
| Output Ripple                                                                                                | $V_O = 2.5$ V                                  | vs. Output Current                                                              | <a href="#">Figure 29</a> |
|                                                                                                              |                                                | vs. Input Voltage                                                               | <a href="#">Figure 30</a> |
| Steady State Operation                                                                                       | $V_{IN} = 3$ V, $V_O = 2.5$ V                  | $R_O = 50 \Omega$                                                               | <a href="#">Figure 31</a> |
|                                                                                                              |                                                | $R_O = 100 \text{ k}\Omega$                                                     | <a href="#">Figure 32</a> |
|                                                                                                              | $V_{IN} = 3$ V, $V_O = 1.8$ V, L = 4.7 $\mu$ H | $R_O = 50 \Omega$                                                               | <a href="#">Figure 33</a> |
| Power Management Response                                                                                    | VRDIV Behavior                                 | $V_O = 2.5$ V                                                                   | <a href="#">Figure 34</a> |
| Transient Response                                                                                           | $V_O = 2.5$ V                                  | Line Transient, $V_{IN} = 3.0$ V $\rightarrow$ 5.0V, $R_{OUT} = 50 \Omega$      | <a href="#">Figure 35</a> |
|                                                                                                              |                                                | Load Transient, $V_{IN} = 4.0$ V, $R_{OUT} = \text{none} \rightarrow 50 \Omega$ | <a href="#">Figure 36</a> |
|                                                                                                              |                                                | IR Pulse Transient, $V_{IN} = 4.0$ V, 200mA transient every 1us                 | <a href="#">Figure 37</a> |
| Startup Behavior                                                                                             | $V_{IN} = 4.0$ V, $V_O = 1.8$ V                | EN1 1 to 0, EN2=1 - Ship mode startup                                           | <a href="#">Figure 38</a> |
|                                                                                                              |                                                | EN1 = 0, EN2 0 to 1 - Standby mode startup                                      | <a href="#">Figure 39</a> |

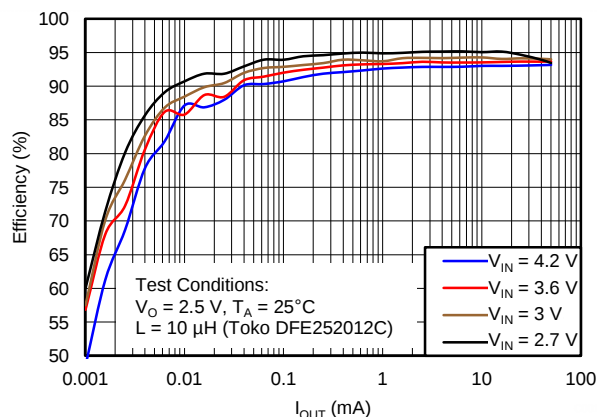


Figure 5. Efficiency Vs Output Current,  $V_{OUT} = 2.5\text{ V}$

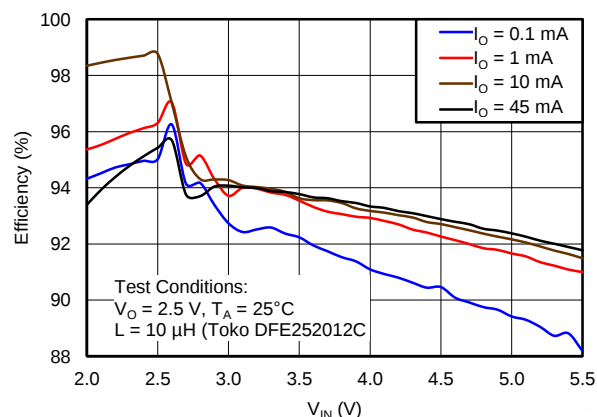


Figure 6. Efficiency vs Input Voltage,  $V_{OUT} = 2.5\text{ V}$

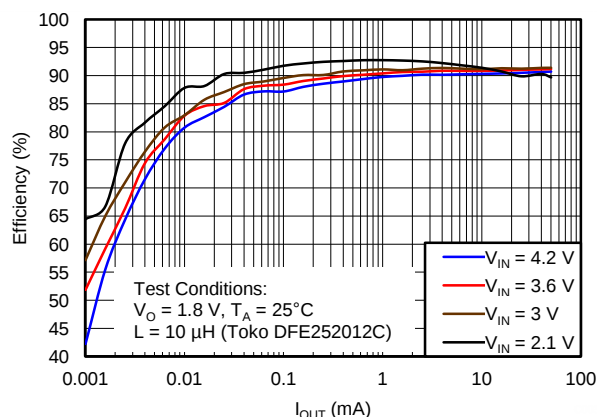


Figure 7. Efficiency Vs Output Current,  $V_{OUT} = 1.8\text{ V}$

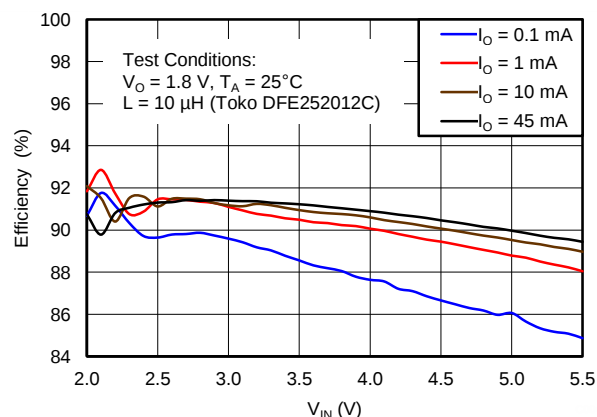


Figure 8. Efficiency vs Input Voltage,  $V_{OUT} = 1.8\text{ V}$

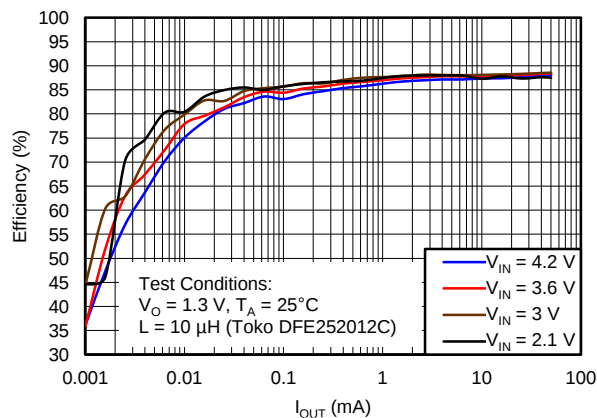


Figure 9. Efficiency Vs Output Current,  $V_{OUT} = 1.3\text{ V}$

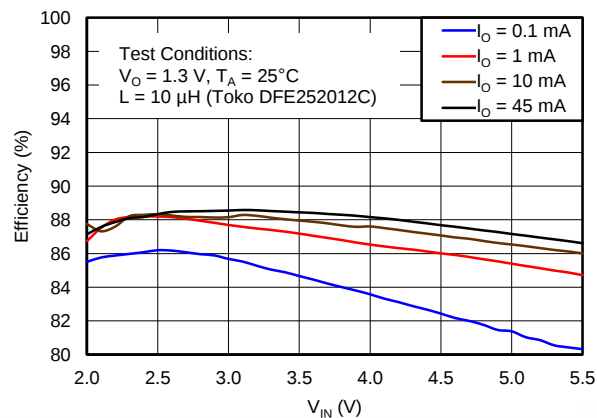


Figure 10. Efficiency vs Input Voltage,  $V_{OUT} = 1.3\text{ V}$

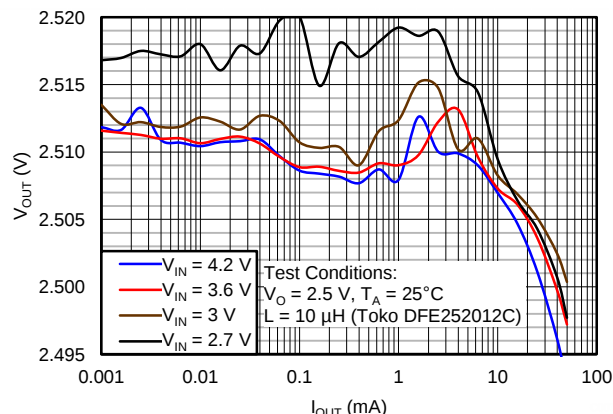


Figure 11. Output Voltage vs Output Current,  $V_{OUT} = 2.5$  V

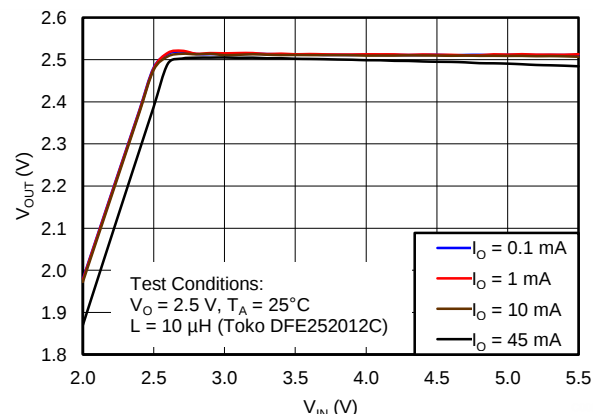


Figure 12. Output Voltage vs Input Voltage,  $V_{OUT} = 2.5$  V

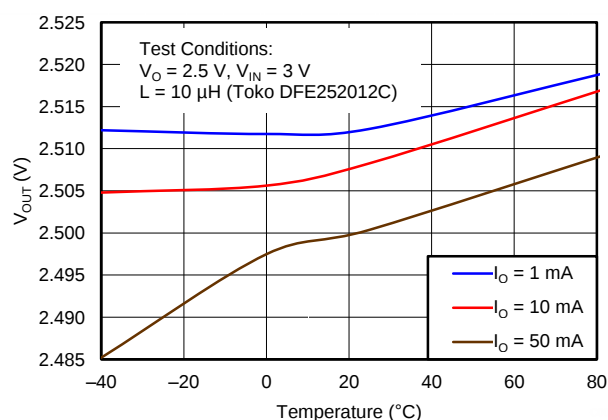


Figure 13. Output Voltage vs Temperature,  $V_{OUT} = 2.5$  V

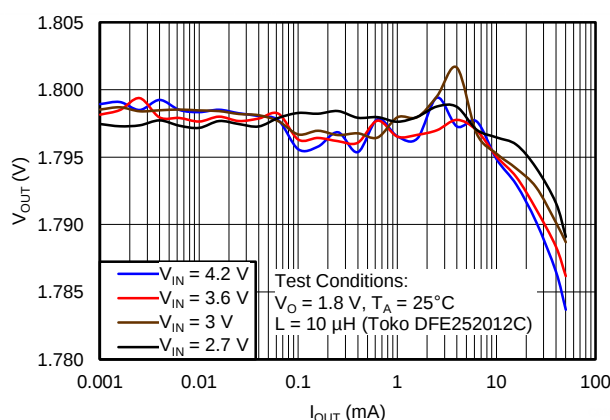


Figure 14. Output Voltage vs Output Current,  $V_{OUT} = 1.8$  V

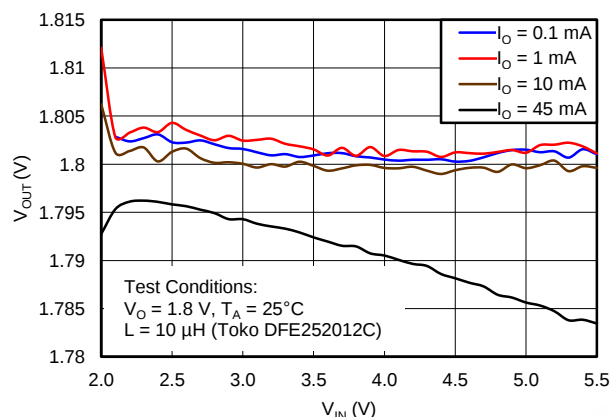


Figure 15. Output Voltage vs Input Voltage,  $V_{OUT} = 1.8$  V

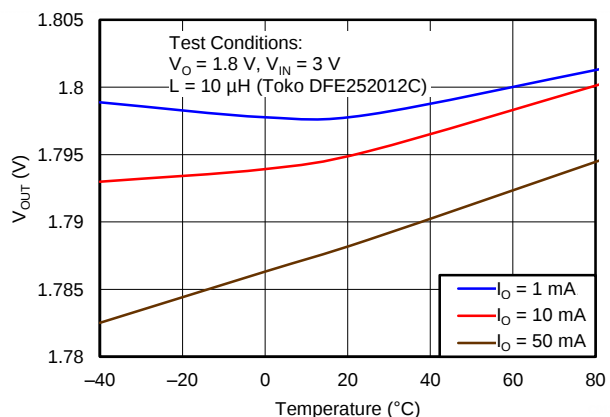
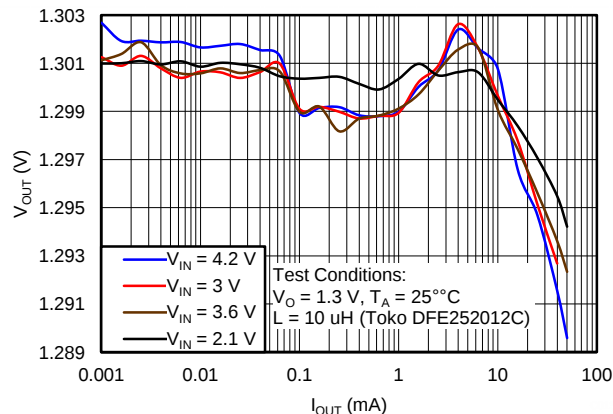
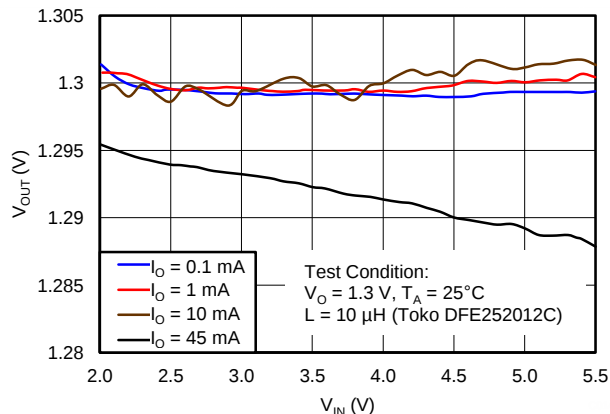


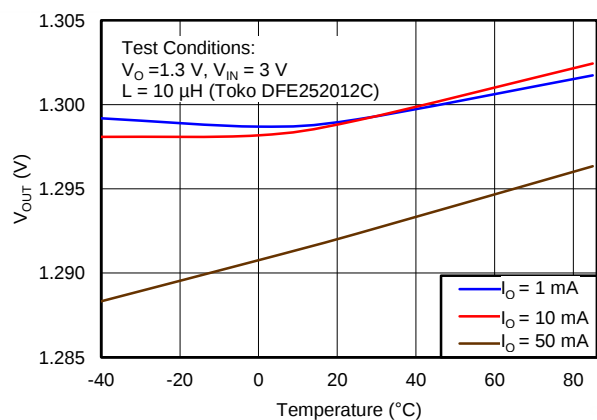
Figure 16. Output Voltage vs Temperature,  $V_{OUT} = 1.8$  V



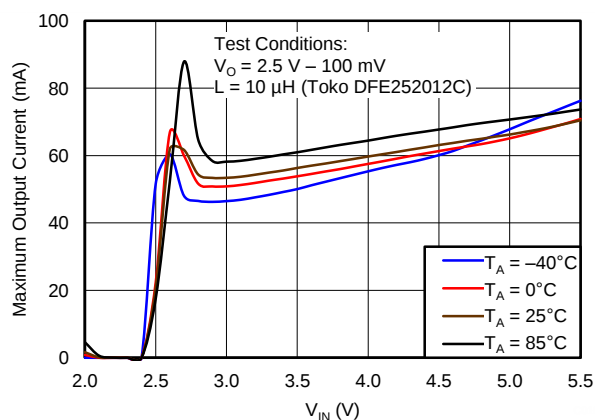
**Figure 17. Output Voltage vs Output Current,  $V_{OUT} = 1.3$  V**



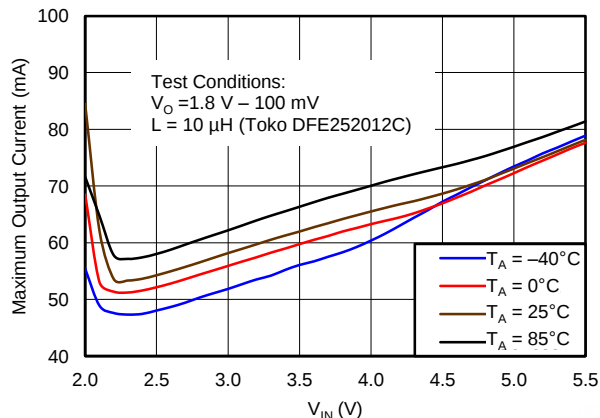
**Figure 18. Output Voltage vs Input Voltage,  $V_{OUT} = 1.3$  V**



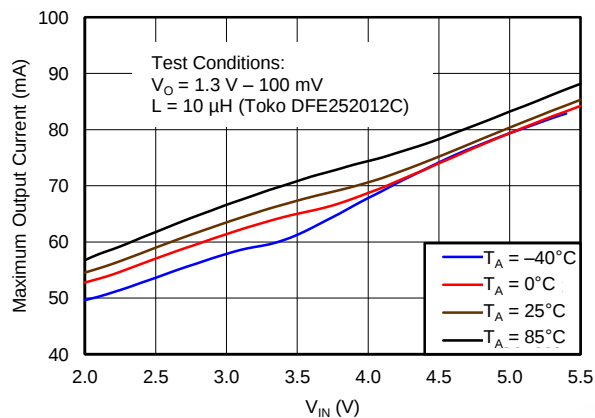
**Figure 19. Output Voltage vs Temperature,  $V_{OUT} = 1.3$  V**



**Figure 20. Maximum Output Current vs. Input Voltage  
 $V_{OUT} = 2.5$  V**



**Figure 21. Maximum Output Current vs. Input Voltage,  
 $V_{OUT} = 1.8$  V**



**Figure 22. Maximum Output Current vs. Input Voltage,  
 $V_{OUT} = 1.3$  V**

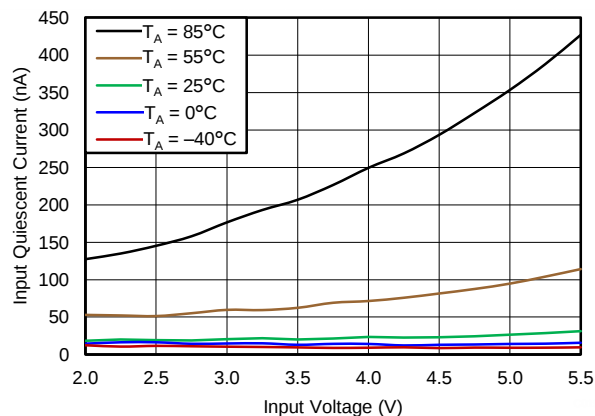


Figure 23. Input Quiescent Current vs. Input Voltage Ship Mode

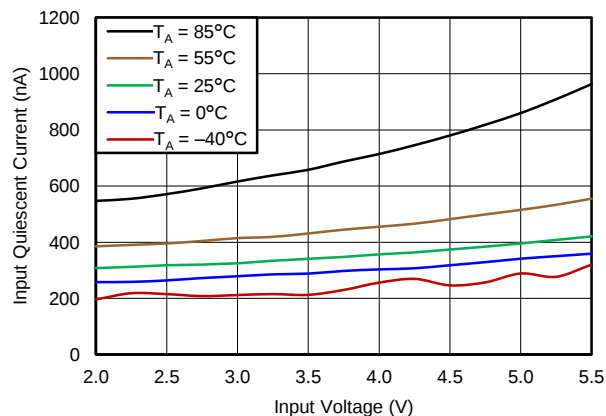


Figure 24. Input Quiescent Current vs. Input Voltage Standby Mode

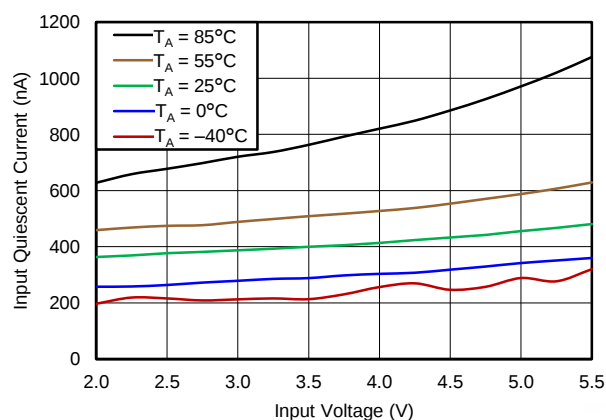


Figure 25. Input Quiescent Current vs. Input Voltage Active Mode

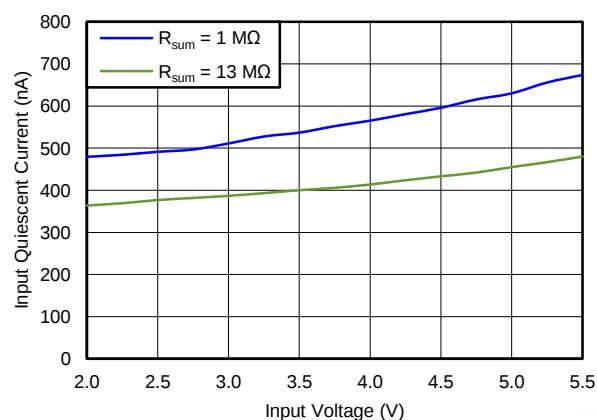


Figure 26. Input Quiescent Current vs. Input Voltage Active Mode where  $R_{SUM} = R1+R2+R3$

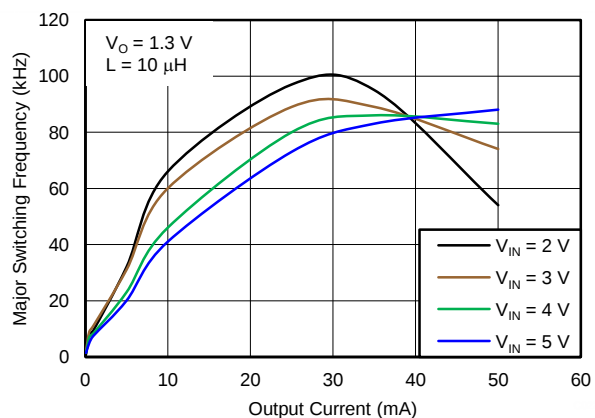


Figure 27. Major Switching Frequency vs Output Current

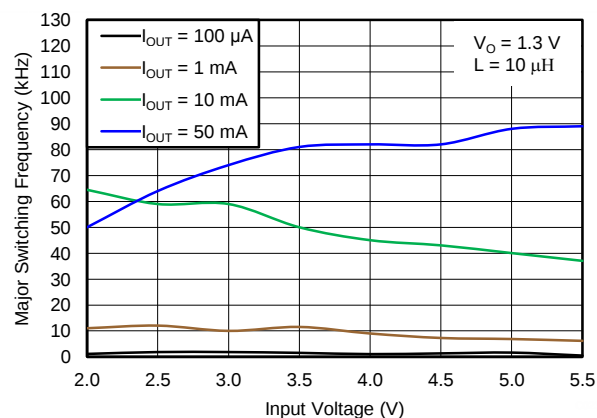


Figure 28. Major Switching Frequency vs Input Voltage

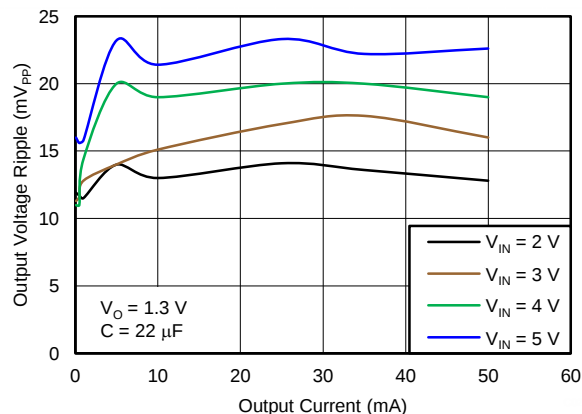


Figure 29. Output Voltage Ripple vs Output Current

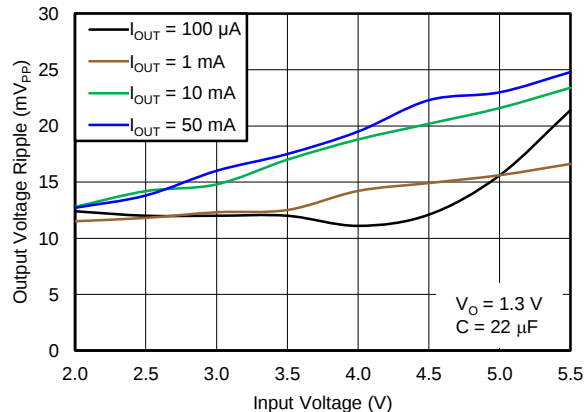


Figure 30. Output Voltage Ripple vs Input Voltage

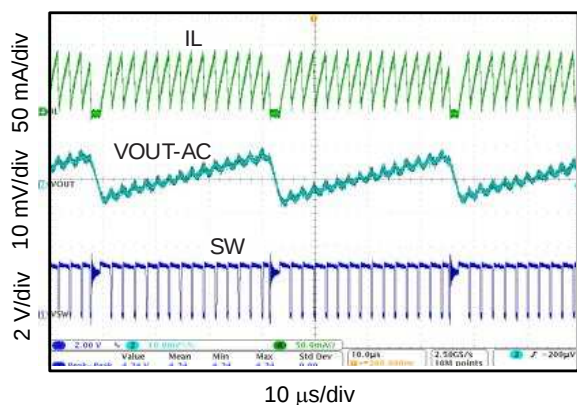


Figure 31. Steady State Operation with  $R_O = 50 \Omega$ ,  $L = 10 \mu\text{H}$

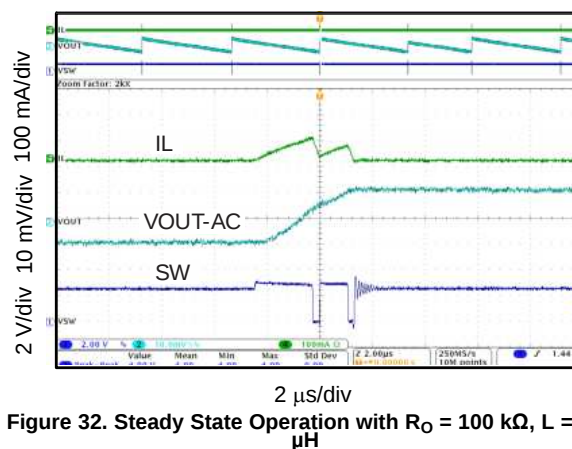


Figure 32. Steady State Operation with  $R_O = 100 \text{ k}\Omega$ ,  $L = 10 \mu\text{H}$

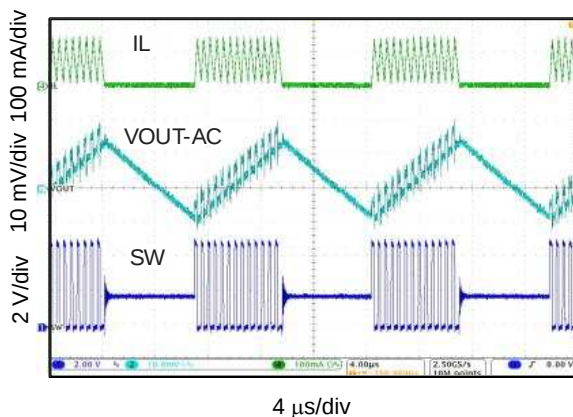


Figure 33. Steady State Operation with  $R_O = 50 \Omega$  and  $L = 4.7 \mu\text{H}$

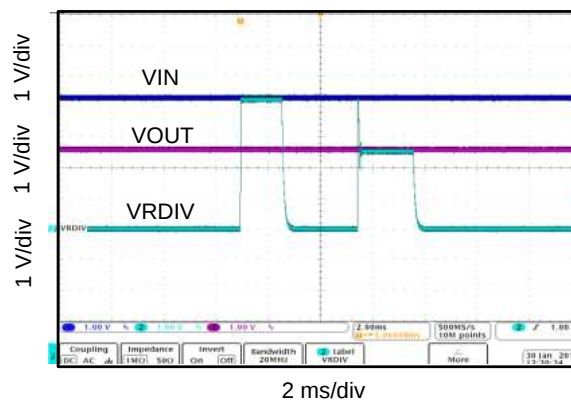


Figure 34. Sampling Waveform

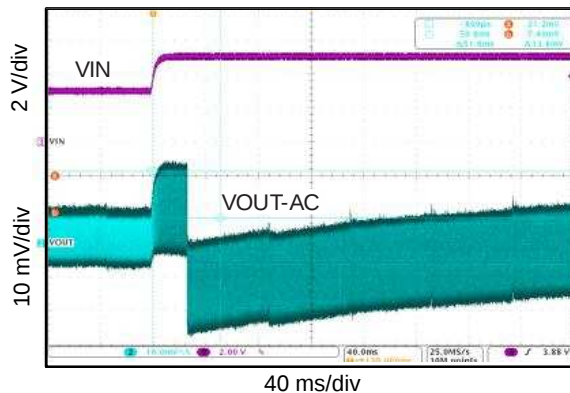


Figure 35. Line Transient Response

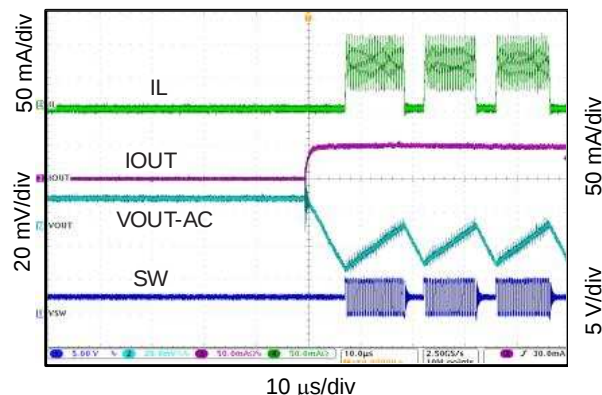


Figure 36. Load Transient Response

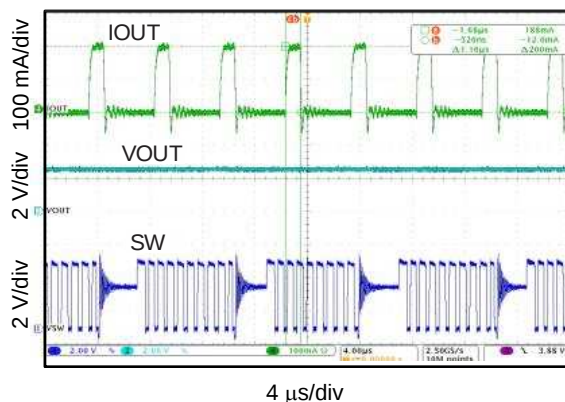


Figure 37. IR Pulse Transient Response

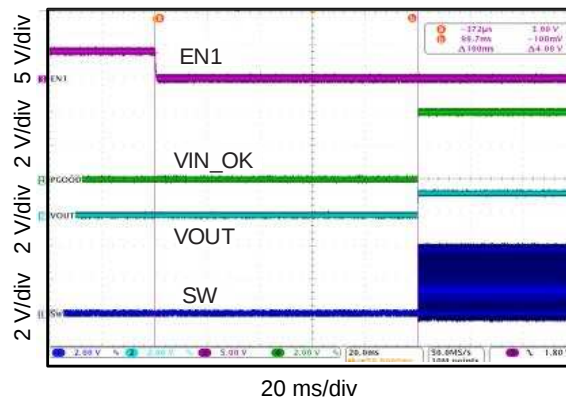


Figure 38. Ship-Mode Startup Behavior

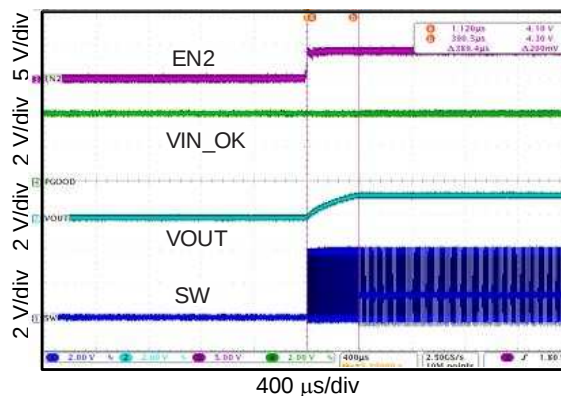


Figure 39. Standby-Mode Startup Behavior

**Table of Graphs for TPS62737**

| Unless otherwise noted, graphs were taken using <a href="#">Figure 2</a> with L = Toko 10 $\mu$ H DFE252012C |                                             |                                                                                  | FIGURE                    |
|--------------------------------------------------------------------------------------------------------------|---------------------------------------------|----------------------------------------------------------------------------------|---------------------------|
| $\eta$                                                                                                       | $V_O = 2.5$ V Efficiency                    | vs. Output Current                                                               | <a href="#">Figure 40</a> |
|                                                                                                              |                                             | vs. Input Voltage                                                                | <a href="#">Figure 41</a> |
|                                                                                                              | $V_O = 1.8$ V Efficiency                    | vs. Output Current                                                               | <a href="#">Figure 42</a> |
|                                                                                                              |                                             | vs. Input Voltage                                                                | <a href="#">Figure 43</a> |
|                                                                                                              | $V_O = 1.3$ V Efficiency                    | vs. Output Current                                                               | <a href="#">Figure 44</a> |
|                                                                                                              |                                             | vs. Input Voltage                                                                | <a href="#">Figure 45</a> |
| $V_{OUT}$ (DC)                                                                                               | $V_O = 2.5$ V                               | vs. Output Current                                                               | <a href="#">Figure 46</a> |
|                                                                                                              |                                             | vs. Input Voltage                                                                | <a href="#">Figure 46</a> |
|                                                                                                              |                                             | vs. Temperature                                                                  | <a href="#">Figure 48</a> |
|                                                                                                              | $V_O = 1.8$ V                               | vs. Output Current                                                               | <a href="#">Figure 49</a> |
|                                                                                                              |                                             | vs. Input Voltage                                                                | <a href="#">Figure 50</a> |
|                                                                                                              |                                             | vs. Temperature                                                                  | <a href="#">Figure 51</a> |
|                                                                                                              | $V_O = 1.3$ V                               | vs. Output Current                                                               | <a href="#">Figure 52</a> |
|                                                                                                              |                                             | vs. Input Voltage                                                                | <a href="#">Figure 53</a> |
|                                                                                                              |                                             | vs. Temperature                                                                  | <a href="#">Figure 54</a> |
| $I_{OUT}$ MAX (DC)                                                                                           | $V_O = 2.5$ V                               | vs. Input Voltage                                                                | <a href="#">Figure 55</a> |
|                                                                                                              | $V_O = 1.8$ V                               |                                                                                  | <a href="#">Figure 56</a> |
|                                                                                                              | $V_O = 1.3$ V                               |                                                                                  | <a href="#">Figure 57</a> |
| Input $I_Q$                                                                                                  | EN1 = 1, EN2 = 0 (Ship Mode)                | vs. Input Voltage                                                                | <a href="#">Figure 58</a> |
|                                                                                                              | EN1 = 0, EN2 = 0 (Standby Mode)             |                                                                                  | <a href="#">Figure 59</a> |
|                                                                                                              | EN1 = 0, EN2 = 1 (Active Mode)              |                                                                                  | <a href="#">Figure 60</a> |
| Switching Frequency                                                                                          | $V_O = 1.8$ V                               | vs. Output Current                                                               | <a href="#">Figure 61</a> |
|                                                                                                              |                                             | vs. Input Voltage                                                                | <a href="#">Figure 62</a> |
| Output Ripple                                                                                                | $V_O = 1.8$ V                               | vs. Output Current                                                               | <a href="#">Figure 64</a> |
|                                                                                                              |                                             | vs. Input Voltage                                                                | <a href="#">Figure 64</a> |
| Steady State Operation                                                                                       | $V_{IN} = 3.6$ V, $V_O = 1.8$ V             | $R_O = 100$ k $\Omega$                                                           | <a href="#">Figure 65</a> |
|                                                                                                              |                                             | $R_O = 9$ $\Omega$                                                               | <a href="#">Figure 66</a> |
| Power Management Response                                                                                    | VRDIV Behavior                              | $V_O = 2.5$ V                                                                    | <a href="#">Figure 67</a> |
| Transient Response                                                                                           | $V_O = 1.8$ V                               | Load Transient, $V_{IN} = 3.6$ V, $R_{OUT} = \text{none} \rightarrow 9$ $\Omega$ | <a href="#">Figure 68</a> |
|                                                                                                              |                                             | Line Transient, $V_{IN} = 3.6$ V $\rightarrow$ 4.6 V, $R_{OUT} = 9$ $\Omega$     | <a href="#">Figure 69</a> |
|                                                                                                              | $V_O = 2.5$ V                               | IR Pulse Transient, $V_{IN} = 4.0$ V, 200 mA transient every 1 $\mu$ s           | <a href="#">Figure 70</a> |
| Startup Behavior                                                                                             | $V_{IN} = 0$ V to 5 V to 0 V, $V_O = 1.8$ V | EN1 = 0, EN2 = 1                                                                 | <a href="#">Figure 71</a> |
|                                                                                                              | $V_{IN} = 3.6$ V, $V_O = 1.8$ V             | EN1 = 1 to 0, EN2 = 1 - Ship mode startup                                        | <a href="#">Figure 72</a> |
|                                                                                                              |                                             | EN1 = 0, EN2 0 to 1 - Standby mode startup                                       | <a href="#">Figure 73</a> |

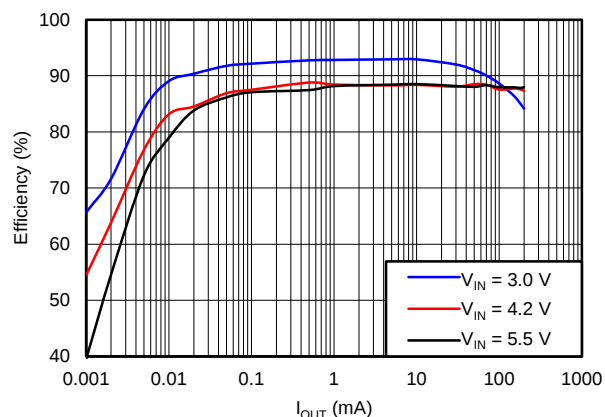


Figure 40. Efficiency Vs Output Current,  $V_{OUT} = 2.5\text{ V}$

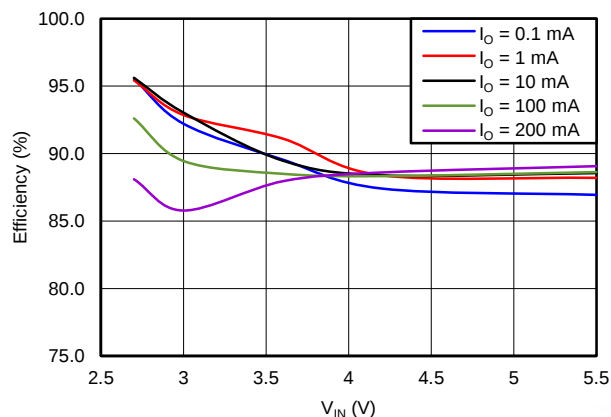


Figure 41. Efficiency vs Input Voltage,  $V_{OUT} = 2.5\text{ V}$

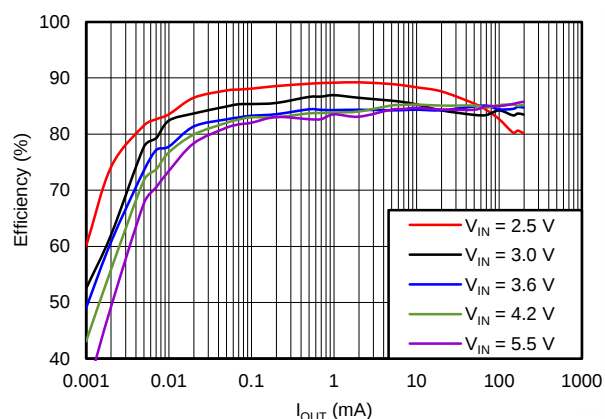


Figure 42. Efficiency Vs Output Current,  $V_{OUT} = 1.8\text{ V}$

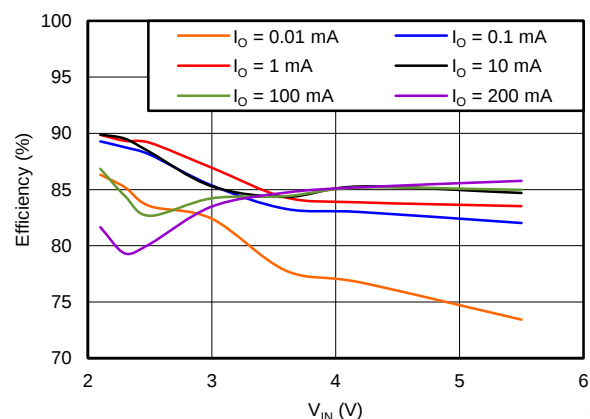


Figure 43. Efficiency vs Input Voltage,  $V_{OUT} = 1.8\text{ V}$

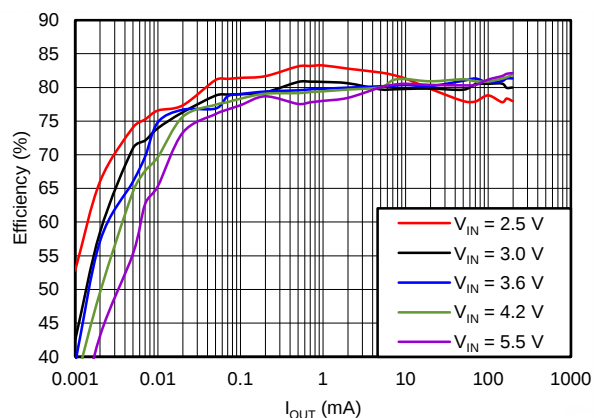


Figure 44. Efficiency Vs Output Current,  $V_{OUT} = 1.3\text{ V}$

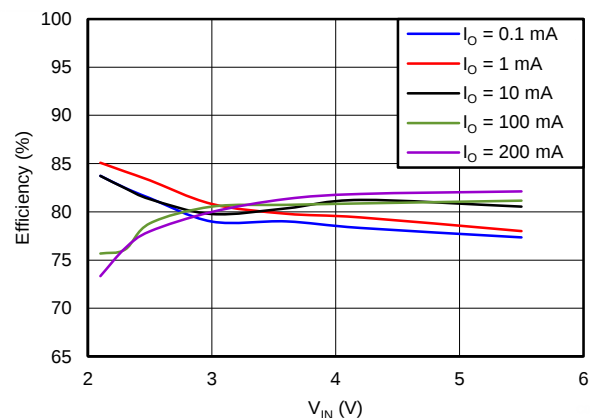


Figure 45. Efficiency vs Input Voltage,  $V_{OUT} = 1.3\text{ V}$

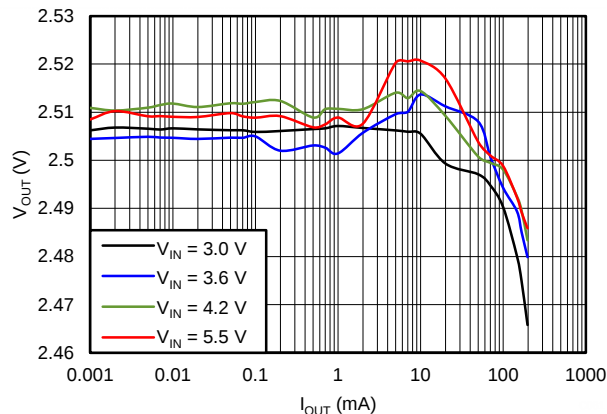


Figure 46. Output Voltage vs Output Current,  $V_{OUT} = 2.5\text{ V}$

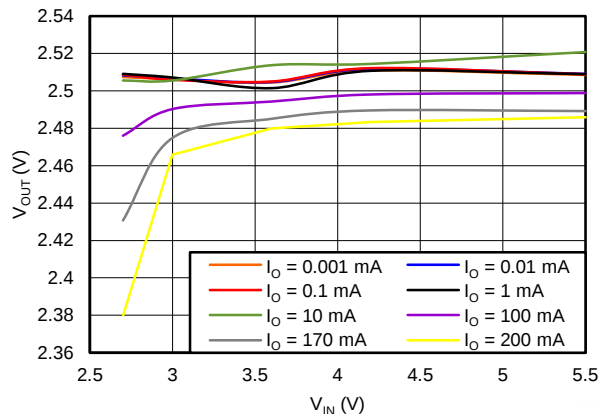


Figure 47. Output Voltage vs Input Voltage,  $V_{OUT} = 2.5\text{ V}$

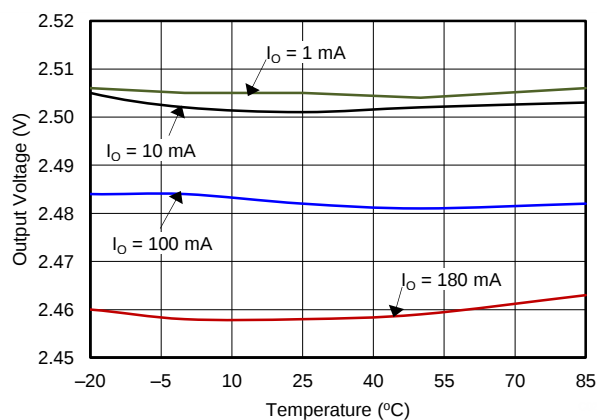


Figure 48. Output Voltage vs Temperature,  $V_{OUT} = 2.5\text{ V}$

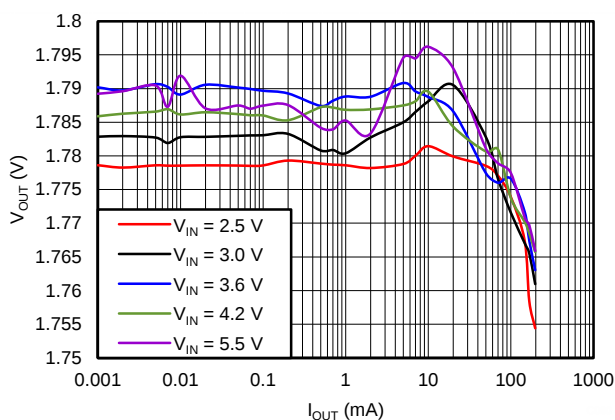


Figure 49. Output Voltage vs Output Current,  $V_{OUT} = 1.8\text{ V}$

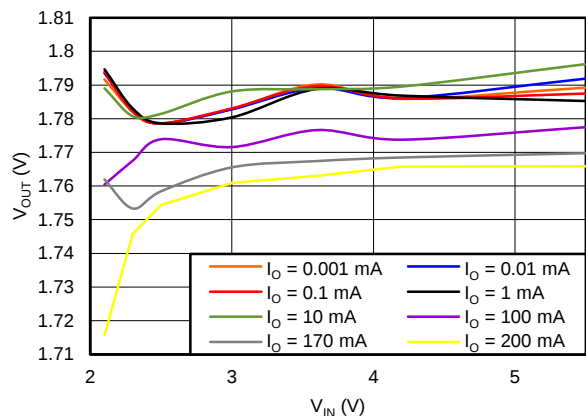


Figure 50. Output Voltage vs Input Voltage,  $V_{OUT} = 1.8\text{ V}$

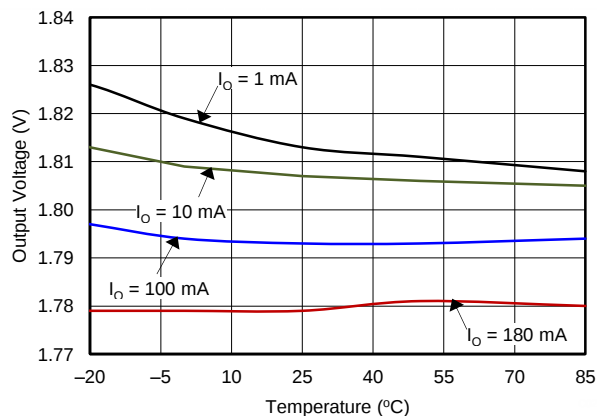


Figure 51. Output Voltage vs Temperature,  $V_{OUT} = 1.8\text{ V}$

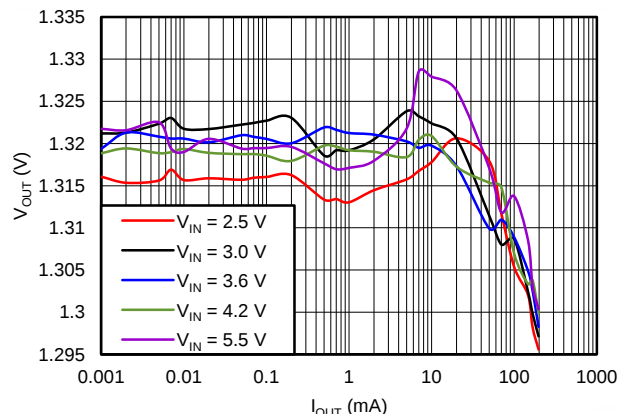


Figure 52. Output Voltage vs Output Current,  $V_{OUT} = 1.3$  V

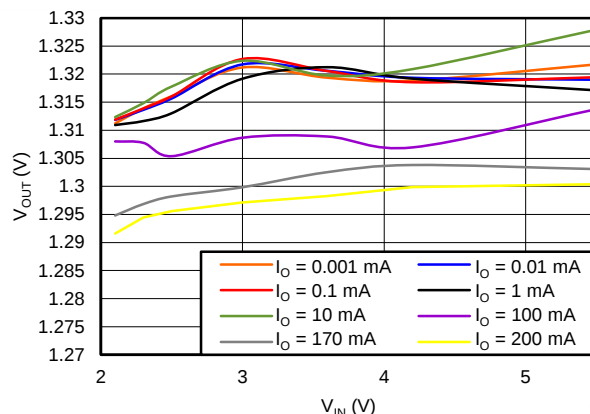


Figure 53. Output Voltage vs Input Voltage,  $V_{OUT} = 1.3$  V

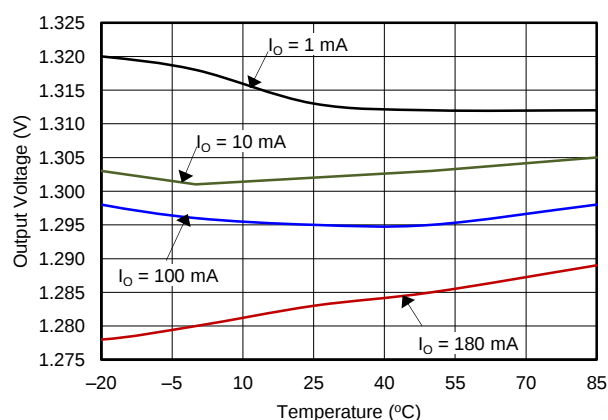


Figure 54. Output Voltage vs Temperature,  $V_{OUT} = 1.3$  V

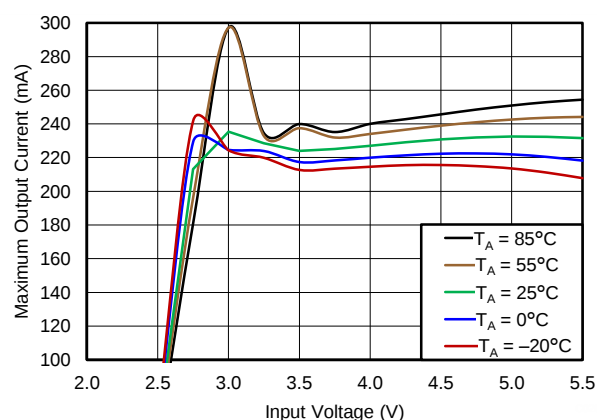


Figure 55. Maximum Output Current vs. Input Voltage,  $V_{OUT} = 2.5$  V

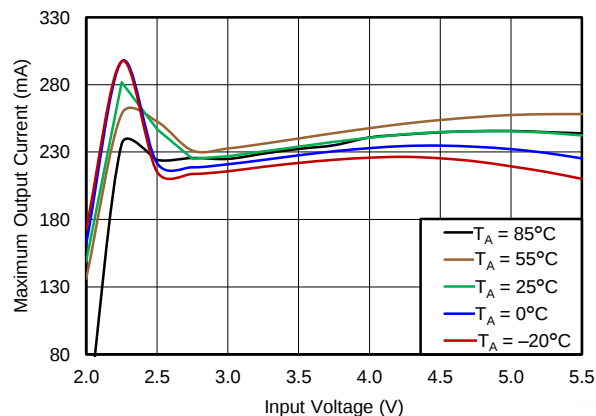


Figure 56. Maximum Output Current vs. Input Voltage,  $V_{OUT} = 1.8$  V

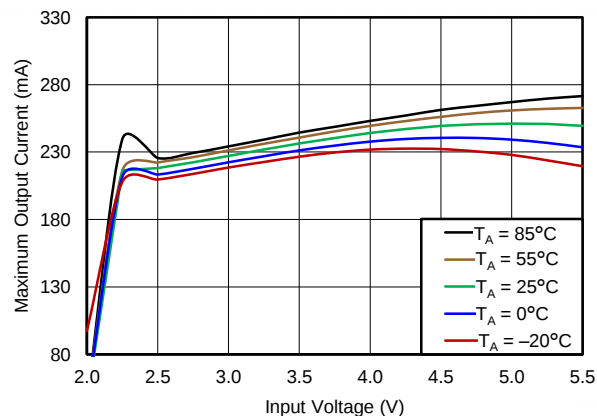
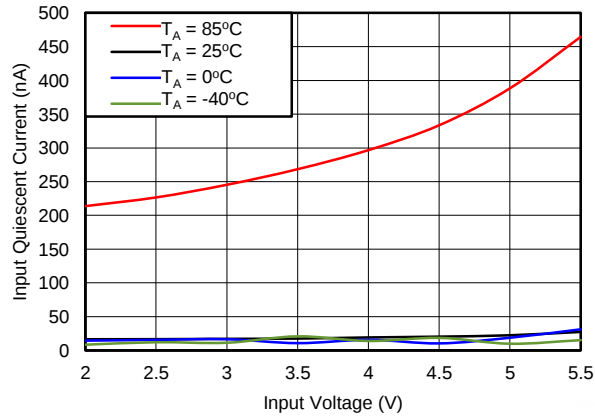
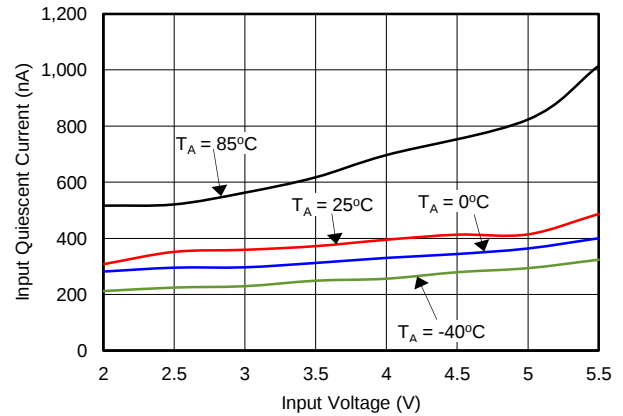


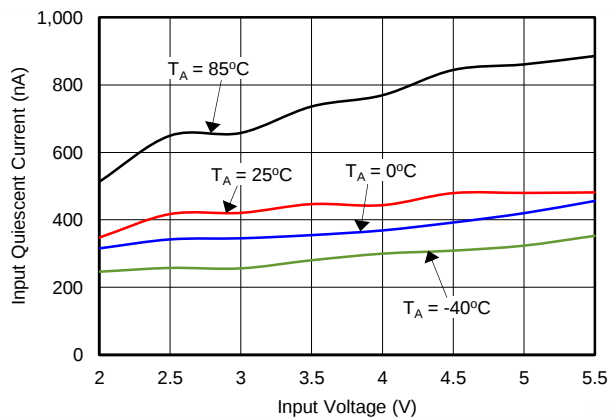
Figure 57. Maximum Output Current vs. Input Voltage,  $V_{OUT} = 1.3$  V



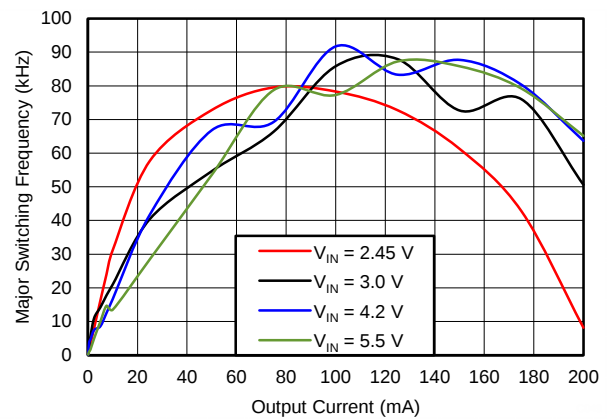
**Figure 58. Input Quiescent Current vs. Input Voltage Ship Mode**



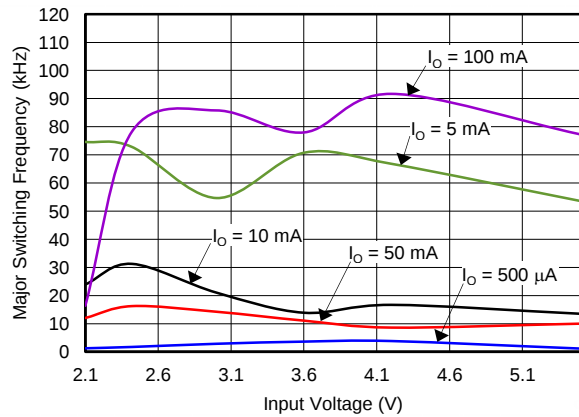
**Figure 59. Input Quiescent Current vs. Input Voltage Standby Mode**



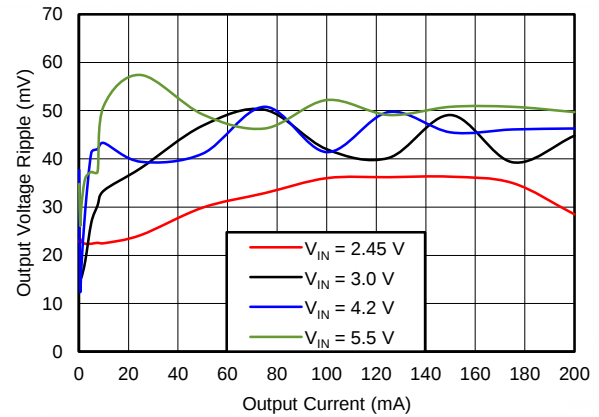
**Figure 60. Input Quiescent Current vs. Input Voltage Active Mode**



**Figure 61. Major Switching Frequency vs Output Current**



**Figure 62. Major Switching Frequency vs Input Voltage**



**Figure 63. Output Voltage Ripple vs Output Current**

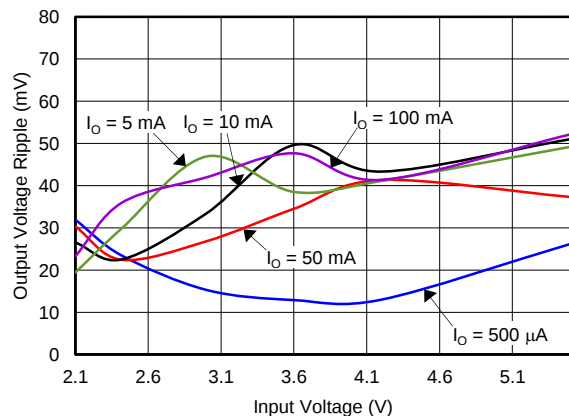


Figure 64. Output Voltage Ripple vs Input Voltage

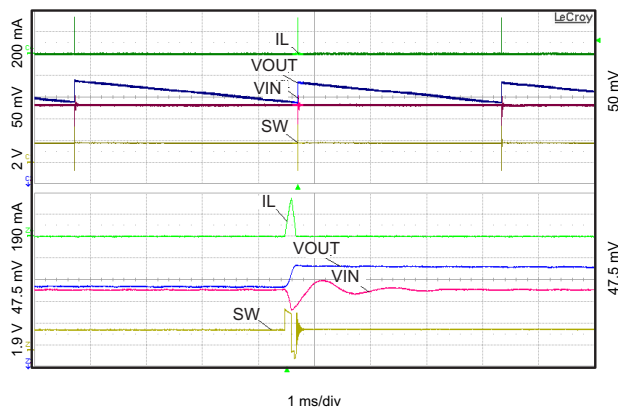


Figure 65. Steady State Operation with  $R_O = 100\text{ k}\Omega$

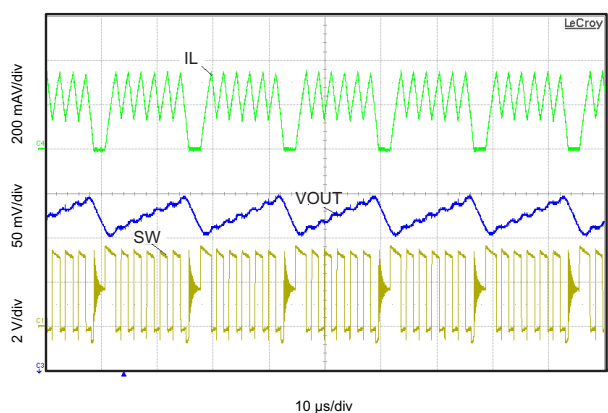


Figure 66. Steady State Operation with  $R_O = 9\text{ }\Omega$

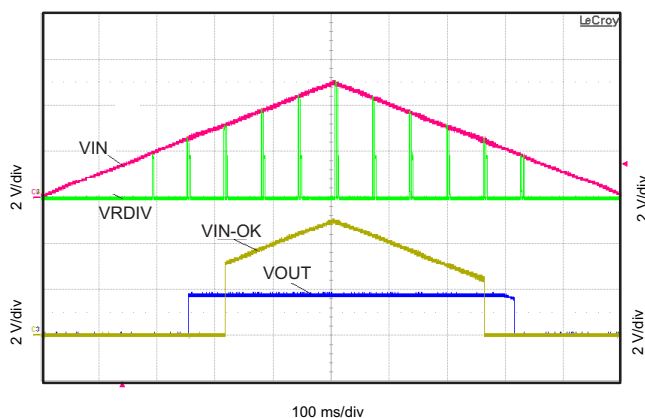


Figure 67. Power Management Response

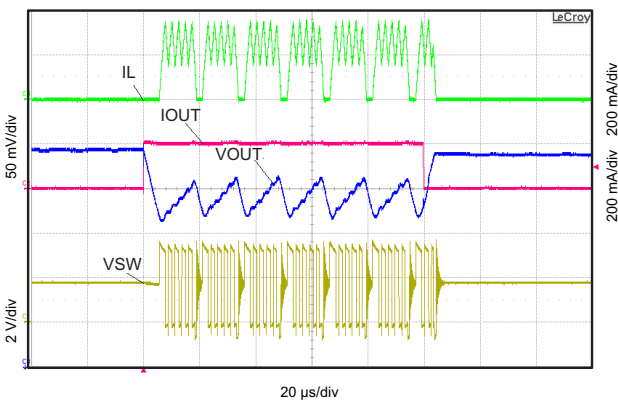


Figure 68. Load Transient Response

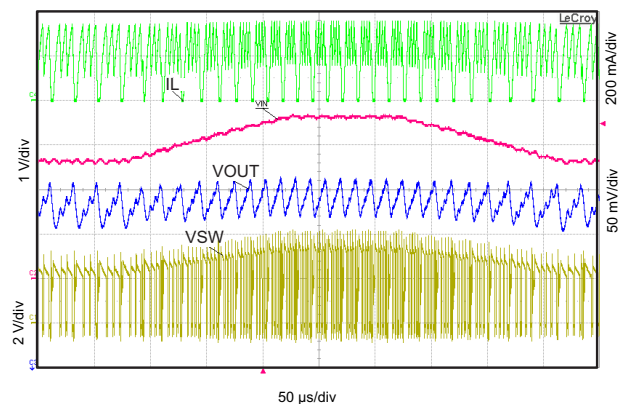
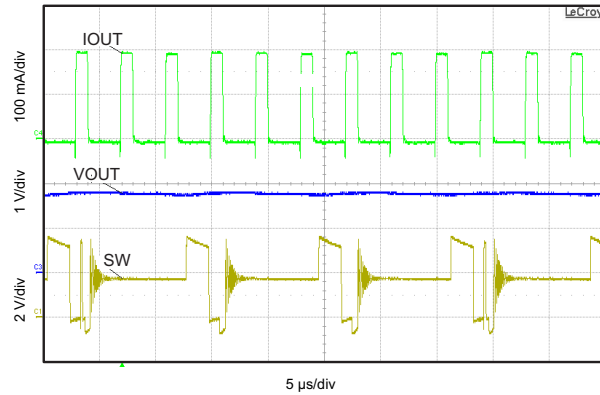
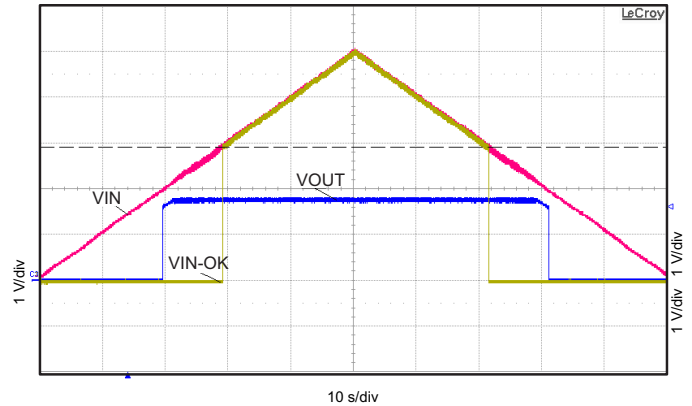


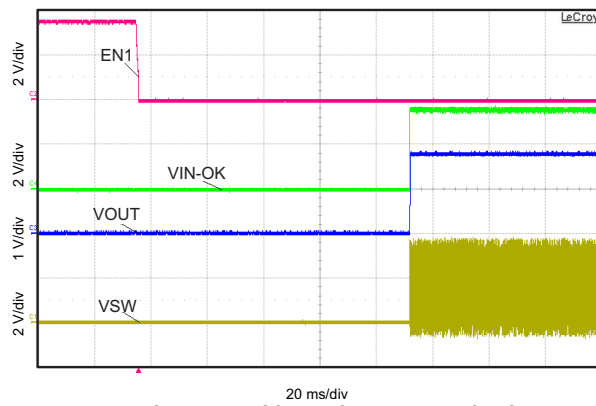
Figure 69. Line Transient Response



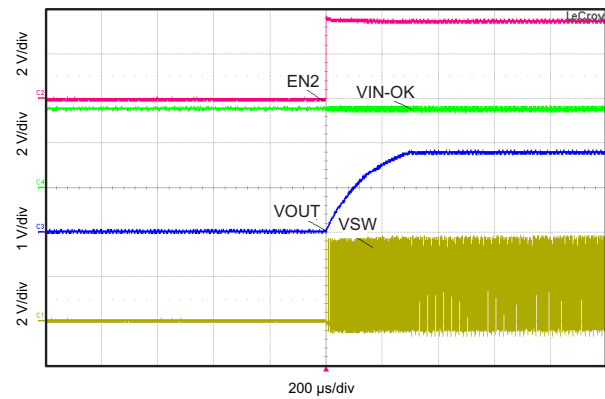
**Figure 70. IR Pulse Transient Response**



**Figure 71. Startup Behavior with Slow Ramping VIN, EN1=0, EN2=1**



**Figure 72. Ship-Mode Startup Behavior**



**Figure 73. Standby-Mode Startup Behavior**

## DETAILED PRINCIPLE OF OPERATION

### Step Down (Buck) Converter Operation

The buck regulator in the TPS6273X takes input power from VIN, steps it down and provides a regulated voltage at the OUT pin. It employs pulse frequency modulation (PFM) control to regulate the voltage close to the desired reference voltage. The reference voltage is set by the user programmed resistor divider. The current through the inductor is controlled through internal current sense circuitry. The peak current in the inductor is controlled to maintain high efficiency of the converter across a wide input current range. The TPS62736 converter delivers an average output current of 50mA with a peak inductor current of 100 mA. The TPS62737 converter delivers an average output current of 200 mA with a peak inductor current of 370 mA. The buck regulator is disabled when the voltage on VIN reaches the UVLO condition. The UVLO level is continuously monitored. The buck regulator continues to operate in pass (100% duty cycle) mode, passing the input voltage to the output, as long as VIN is greater than UVLO and less than VIN minus I<sub>OUT</sub> times R<sub>DS(on)</sub> of the high-side FET (i.e., VIN - I<sub>OUT</sub> × R<sub>DS(on)-HS</sub>). In order to save power from being dissipated through other IC's on this supply rail while allowing for a faster wake up time, the buck regulator can be enabled and disabled via the EN2 pin for systems that desire to completely turn off the regulated output.

### Nano-Power Management and Efficiency

The high efficiency of the TPS6273X is achieved via the proprietary Nano-Power management circuitry and algorithm. This feature essentially samples and holds all references in order to reduce the average quiescent current. That is, the internal circuitry is only active for a short period of time and then off for the remaining period of time at the lowest feasible duty cycle. A portion of this feature can be observed in [Figure 34](#) where the VRDIV node is monitored. Here the VRDIV node provides a connection to the input (larger voltage level) and generates the output reference (lower voltage level) for a short period of time. The divided down value of input voltage is compared to VBIAS and the output voltage reference is sampled and held to get the VOUT\_SET point. Since this biases a resistor string, the current through these resistors is only active when the Nano-Power management circuitry makes the connection—hence reducing the overall quiescent current due to the resistors. This process repeats every 64 ms. Similarly, the VIN\_OK level is monitored every 64ms, as shown in [Figure 67](#).

The efficiency versus output current and versus input voltage are plotted for three different output voltages for both the TPS62736 and TPS62737 in the Typical Characteristics section. All data points were captured by averaging the overall input current. This must be done due to the periodic biasing scheme implemented via the Nano-Power management circuitry. The input current efficiency data was gathered using a source meter set to average over at least 25 samples and at the highest accuracy sampling rate. Each data point takes a long period of time to gather in order to properly measure the resulting input current when calculating the efficiency.

### Programming OUT Regulation Voltage and VIN\_OK

To set the proper output regulation voltage and input voltage power good comparator, the external resistors must be carefully selected. [Figure 1](#) illustrates an application diagram which uses the minimal resistor count for setting both VOUT and VIN\_OK. Note that VBIAS is nominally 1.21V per the electrical specification table. Referring to [Figure 1](#), the OUT dc set point is given by:

$$V_{OUT} = V_{BIAS} \left( \frac{R_1 + R_2 + R_3}{R_1 + R_2} \right) \quad (1)$$

The VIN\_OK setting is given by:

$$V_{IN\_OK} = V_{BIAS} \left( \frac{R_1 + R_2 + R_3}{R_1} \right) \quad (2)$$

The sum of the resistors is recommended to be no greater than 13 MΩ, that is, R<sub>SUM</sub> = R<sub>1</sub> + R<sub>2</sub> + R<sub>3</sub> = 13 MΩ. Due to the sampling operation of the output resistors, lowering R<sub>SUM</sub> only increases quiescent current slightly as can be seen in [Figure 26](#). Higher resistors may result in poor output voltage regulation and/or input voltage power good threshold accuracies due to noise pickup via the high impedance pins or reduction of effective resistance due to parasitic resistances created from board assembly residue. See Layout Considerations section for more details.

If it is preferred to separate the VOUT and VIN\_OK resistor strings, two separate strings of resistors could be used as shown in [Figure 3](#). The OUT dc set point is then given by [Equation 3](#):

$$V_{OUT} = V_{BIAS} \left( \frac{R_3 + R_4}{R_4} \right) \quad (3)$$

The VIN\_OK setting is then given by [Equation 4](#):

$$VIN\_OK = V_{BIAS} \left( \frac{R_1 + R_2}{R_1} \right) \quad (4)$$

If it is preferred to disable the VIN\_OK setting, the VIN\_OK\_SET pin can be tied to VIN as shown in [Figure 4](#). To set VOUT in this configuration, use [Equation 3](#). To tighten the dc set point accuracy, use external resistors with better than 1% resistor tolerance. Since output voltage ripple has a large effect on input line regulation and the output load regulation, using a larger output capacitor will improve both line and load regulation.

## Enable Controls

There are two enable pins implemented in the TPS6273X in order to maximize the flexibility of control for the system. The EN1 pin is considered to be the chip enable. If EN1 is set to a 1 then the entire chip is placed into ship mode. If EN1 is 0 then the chip is enabled. EN2 enables and disables the switching of the buck converter. When EN2 is low, the internal circuitry remains ON and the VIN\_OK indicator still functions. This can be used to disable down-stream electronics in case of a low input supply condition. When EN2 is 1, the buck converter operates normally.

**Table 1. Enable Functionality Table**

| EN1 PIN | EN2 PIN | FUNCTIONAL STATE                                                                   |
|---------|---------|------------------------------------------------------------------------------------|
| 0       | 0       | Partial standby mode. Buck switching converter is off, but VIN_OK indication is on |
| 0       | 1       | Buck mode and VIN_OK enabled                                                       |
| 1       | x       | Full standby mode. Switching converter and VIN_OK indication is off (ship mode)    |

## Startup Behavior

The TPS6273X has two startup responses: 1) from the ship-mode state (EN1 transitions from high to low), and 2) from the standby state (EN2 transitions from low to high). The first startup response out of the ship-mode state has the longest time duration due to the internal circuitry being disabled. This response is shown in [Figure 38](#) for the TPS62736 and [Figure 72](#) for the TPS62737. The startup time takes approximately 100ms due to the internal Nano-Power management circuitry needing to complete the 64 ms sample and hold cycle.

Startup from the standby state is shown in [Figure 39](#) for the TPS62736 and [Figure 73](#) for the TPS62737. This response is much faster due to the internal circuitry being pre-enabled. The startup time from this state is entirely dependent on the size of the output capacitor. The larger the capacitor, the longer it will take to charge during startup. The TPS6273X can startup into a pre-biased output voltage.

## Steady State Operation and Cycle by Cycle Behavior

The steady state operation at full load is shown in [Figure 31](#) for the TPS62736 and [Figure 66](#) for TPS62737. This plot highlights the inductor current waveform, the output voltage ripple, and the switching node. The output voltage is maintained by charging and discharging the output capacitor at a primary duty cycle (major frequency) which in turn dictates the output voltage ripple frequency. When VOUT is increasing in value, the output capacitor is charged by the hysteretic buck controller. This is achieved by controlling the peak cycle-by-cycle inductor current to  $I_{LIM}$ . The cycle-by-cycle current is maintained by turning on and off the high side FET at a secondary duty cycle (minor frequency). When VOUT reaches a peak value, all hysteretic control is disabled until a minimum value is reached. The rate at which the converter stays off is dictated by the load and the size of the output capacitor. At heavier output loads (larger output current), the time the converter is off is smaller when compared to light load conditions. The light load condition is shown in [Figure 32](#) for the TPS62736 and [Figure 65](#) for the TPS62737. Note that the converter is inactive for a longer period of time when compared to the active time.

The minor switching frequency is of concern when choosing the inductor. This maximum switching frequency is 1 MHz. The major switching frequency dictates the voltage ripple frequency. [Figure 27](#) and [Figure 28](#) show the major switching frequency versus load current and input voltage for the TPS62736, respectively. [Figure 61](#) and [Figure 62](#) show the major switching frequency versus load current and input voltage for the TPS62737, respectively.

## Inductor Selection

The internal control circuitry is designed to control the switching behavior with a nominal inductance of  $10\ \mu\text{H} \pm 20\%$ . The inductor's saturation current should be at least 25% higher than the maximum cycle-by-cycle current limit per the electrical specs table ( $I_{\text{LIM}}$ ) in order to account for load transients. Since this device is a hysteretic controller, it is a naturally stable system (single order transfer function). However, the smaller the inductor value is, the faster the switching currents are. The speed of the peak current detect circuit sets the TPS62736 inductor's lower bound to  $4.7\ \mu\text{H}$ . When using a  $4.7\ \mu\text{H}$ , the peak inductor current will increase when compared to that of a  $10\ \mu\text{H}$  inductor. The steady-state operation with a  $4.7\ \mu\text{H}$  inductor with a 50 mA load for the TPS62736 is shown in [Figure 33](#).

A list of inductors recommended for this device is shown in [Table 2](#).

**Table 2.**

| Inductance ( $\mu\text{H}$ ) | Dimensions (mm) | Part Number       | Manufacturer |
|------------------------------|-----------------|-------------------|--------------|
| 10                           | 2.0 x 2.5 x 1.2 | DFE252012C-H-100M | Toko         |
| 10                           | 4.0x4.0x1.7     | LPS4018-103M      | Coilcraft    |
| 4.7 (TPS62736 only)          | 2.0 x 2.5 x 1.2 | DFE252012R-H-4R7M | Toko         |

## Output Capacitor Selection

The output capacitor is chosen based on transient response behavior and ripple magnitude. The lower the capacitor value, the larger the ripple will become and the larger the droop will be in the case of a transient response. It is recommended to use at least a  $22\ \mu\text{F}$  output capacitor for most applications.

## Input Capacitor Selection

The bulk input capacitance is recommended to be a minimum of  $4.7\ \mu\text{F} \pm 20\%$  for the TPS62736 and  $22\ \mu\text{F} \pm 20\%$  for the TPS62737. This bulk capacitance is used to suppress the lower frequency transients produced by the switching converter. There is no upper bound to the input bulk capacitance. In addition, a high frequency bypass capacitor of  $0.1\ \mu\text{F}$  is recommended in parallel with the bulk capacitor. The high frequency bypass is used to suppress the high frequency transients produced by the switching converter.

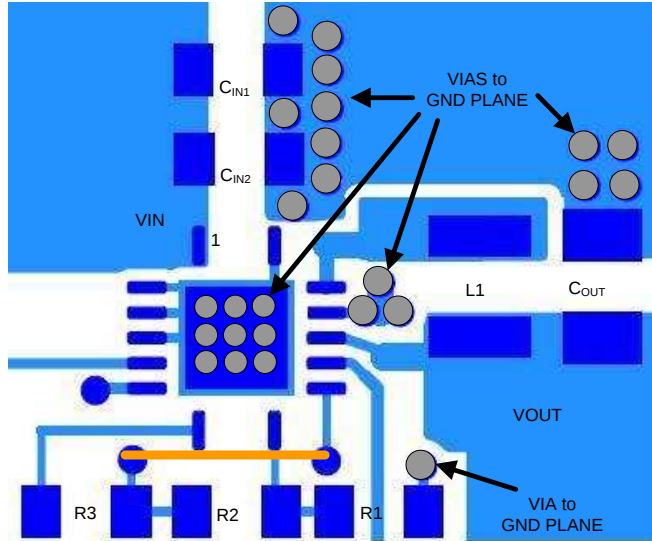
## Layout and PCB Assembly Considerations

To minimize switching noise generation, the step-down converter (buck) power stage external components must be carefully placed. The most critical external component for a buck power stage is its input capacitor. The bulk input capacitor ( $C_{\text{IN1}}$ ) and high frequency decoupling capacitor ( $C_{\text{IN2}}$ ) must be placed as close as possible between the power stage input (IN pin 1) and ground (VSS pin 12). Next, the inductor (L1) must be placed as close as possible between the switching node (SW pin 13) and the output voltage (OUT pin 11). Finally, the output capacitor ( $C_{\text{OUT}}$ ) should be placed as close as possible between the output voltage (OUT pin 11) and GND (VSS pin 12). In the diagram below, the input and output capacitor grounds are connected to VSS pin 12 through vias to the PCB's bottom layer ground plane.

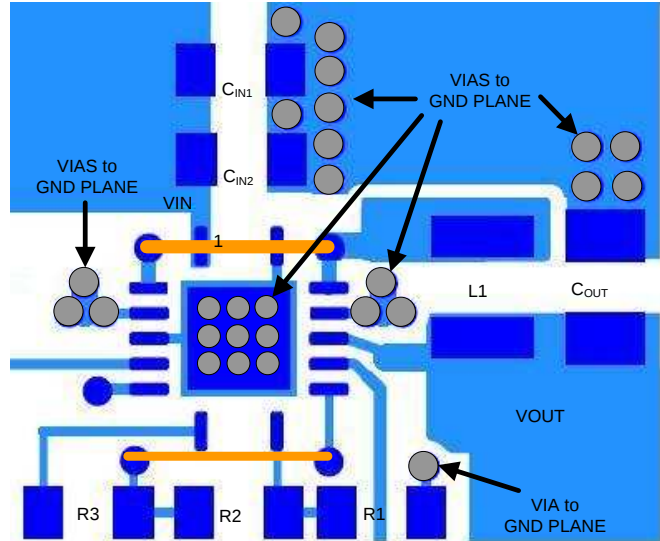
To minimize noise pickup by the high impedance voltage setting nodes (VIN\_OK\_SET pin 8 and VOUT\_SET pin 9), the external resistors (R1, R2 and R3) should be placed so that the traces connecting the midpoints of the string are as short as possible. In the diagram below, the connection to VOUT\_SET is by a bottom layer trace.

The remaining pins are either NC pins, that should be connected to the PowerPAD™ as shown below, or digital signals with minimal layout restrictions.

In order to maximize efficiency at light load, the use of voltage level setting resistors  $> 1\text{M}\Omega$  is recommended. However, during board assembly, contaminants such as solder flux and even some board cleaning agents can leave residue that may form parasitic resistors across the physical resistors and/or from one end of a resistor to ground, especially in humid, fast airflow environments. This can result in the voltage regulation and threshold levels changing significantly from those expected per the installed resistor values. Therefore, it is highly recommended that no ground planes be poured near the voltage setting resistors. In addition, the boards must be carefully cleaned, possibly rotated at least once during cleaning, and then rinsed with de-ionized water until the ionic contamination of that water is well above 50 MOhm. If this is not feasible, then it is recommended that the sum of the voltage setting resistors be reduced to at least 5X below the measured ionic contamination.



**Figure 74. Recommended Layout, TPS62736**



**Figure 75. Recommended Layout, TPS62737**

## REVISION HISTORY

| Changes from Original (October 2012) to Revision A                                                                                                                                                                                                                                                                      | Page                     |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|
| <ul style="list-style-type: none"> <li>Changed the device From: Preview To: Active</li> </ul>                                                                                                                                                                                                                           | 1                        |
| Changes from Revision A (March 2013) to Revision B                                                                                                                                                                                                                                                                      | Page                     |
| <ul style="list-style-type: none"> <li>Added the TPS62737 Pinout information</li> <li>Added the TPS62737 Application Circuit, <a href="#">Figure 2</a></li> <li>Added graphs for TPS62737 to the Typical Characteristics</li> <li>Changed <a href="#">Figure 74</a></li> <li>Added <a href="#">Figure 75</a></li> </ul> | 6<br>9<br>17<br>27<br>27 |

## PACKAGING INFORMATION

| Orderable Device | Status<br>(1) | Package Type | Package<br>Drawing | Pins | Package<br>Qty | Eco Plan<br>(2)            | Lead/Ball Finish | MSL Peak Temp<br>(3) | Op Temp (°C) | Device Marking<br>(4/5) | Samples                 |
|------------------|---------------|--------------|--------------------|------|----------------|----------------------------|------------------|----------------------|--------------|-------------------------|-------------------------|
| TPS62736RGYR     | ACTIVE        | VQFN         | RGY                | 14   | 3000           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU        | Level-2-260C-1 YEAR  | -40 to 85    | 62736                   | <a href="#">Samples</a> |
| TPS62736RGYT     | ACTIVE        | VQFN         | RGY                | 14   | 250            | Green (RoHS<br>& no Sb/Br) | CU NIPDAU        | Level-2-260C-1 YEAR  | -40 to 85    | 62736                   | <a href="#">Samples</a> |
| TPS62737RGYR     | ACTIVE        | VQFN         | RGY                | 14   | 3000           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU        | Level-2-260C-1 YEAR  | -20 to 85    | 62737                   | <a href="#">Samples</a> |
| TPS62737RGYT     | ACTIVE        | VQFN         | RGY                | 14   | 250            | Green (RoHS<br>& no Sb/Br) | CU NIPDAU        | Level-2-260C-1 YEAR  | -20 to 85    | 62737                   | <a href="#">Samples</a> |

(1) The marketing status values are defined as follows:

**ACTIVE:** Product device recommended for new designs.

**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.

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

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

**TBD:** The Pb-Free/Green conversion plan has not been defined.

**Pb-Free (RoHS):** TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

**Pb-Free (RoHS Exempt):** This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

**Green (RoHS & no Sb/Br):** TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

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

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

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

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

**TAPE AND REEL INFORMATION**


\*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 |
|--------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| TPS62736RGYR | VQFN         | RGY             | 14   | 3000 | 330.0              | 12.4               | 3.75    | 3.75    | 1.15    | 8.0     | 12.0   | Q1            |
| TPS62736RGYT | VQFN         | RGY             | 14   | 250  | 180.0              | 12.4               | 3.75    | 3.75    | 1.15    | 8.0     | 12.0   | Q1            |
| TPS62737RGYR | VQFN         | RGY             | 14   | 3000 | 330.0              | 12.4               | 3.75    | 3.75    | 1.15    | 8.0     | 12.0   | Q1            |
| TPS62737RGYT | VQFN         | RGY             | 14   | 250  | 180.0              | 12.4               | 3.75    | 3.75    | 1.15    | 8.0     | 12.0   | Q1            |

## TAPE AND REEL BOX DIMENSIONS

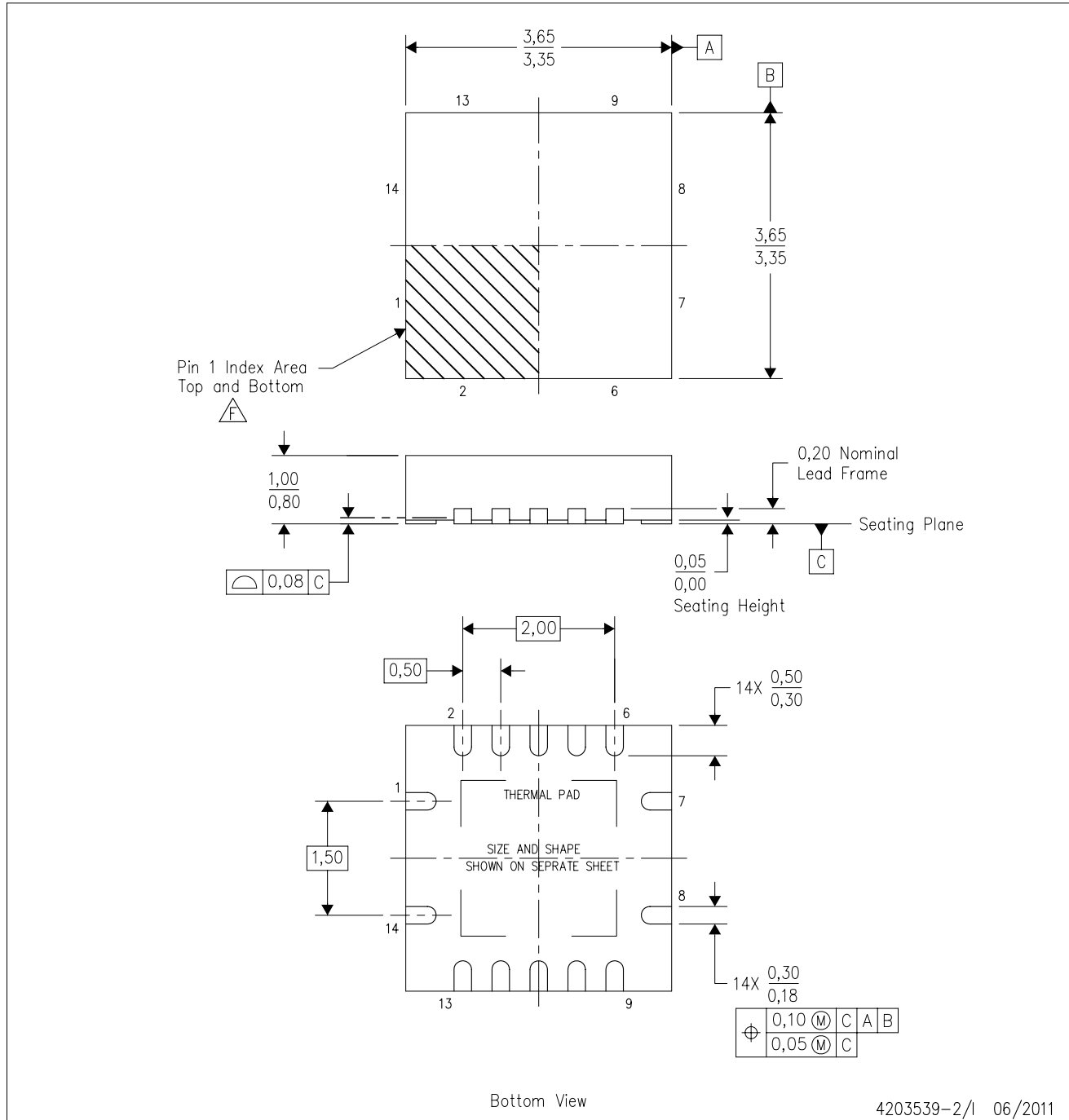


\*All dimensions are nominal

| Device       | Package Type | Package Drawing | Pins | SPQ  | Length (mm) | Width (mm) | Height (mm) |
|--------------|--------------|-----------------|------|------|-------------|------------|-------------|
| TPS62736RGYR | VQFN         | RGY             | 14   | 3000 | 367.0       | 367.0      | 35.0        |
| TPS62736RGYT | VQFN         | RGY             | 14   | 250  | 210.0       | 185.0      | 35.0        |
| TPS62737RGYR | VQFN         | RGY             | 14   | 3000 | 367.0       | 367.0      | 35.0        |
| TPS62737RGYT | VQFN         | RGY             | 14   | 250  | 210.0       | 185.0      | 35.0        |

RGY (S-PVQFN-N14)

PLASTIC QUAD FLATPACK NO-LEAD



4203539-2/I 06/2011

- 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.
  - Pin 1 identifiers are located on both top and bottom of the package and within the zone indicated. The Pin 1 identifiers are either a molded, marked, or metal feature.
  - Package complies to JEDEC MO-241 variation BA.

RGY (S-PVQFN-N14)

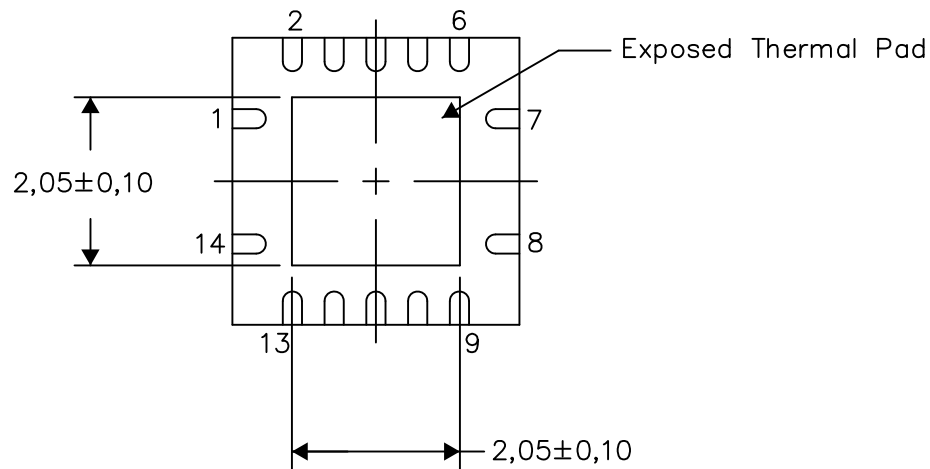
PLASTIC QUAD FLATPACK NO-LEAD

## 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

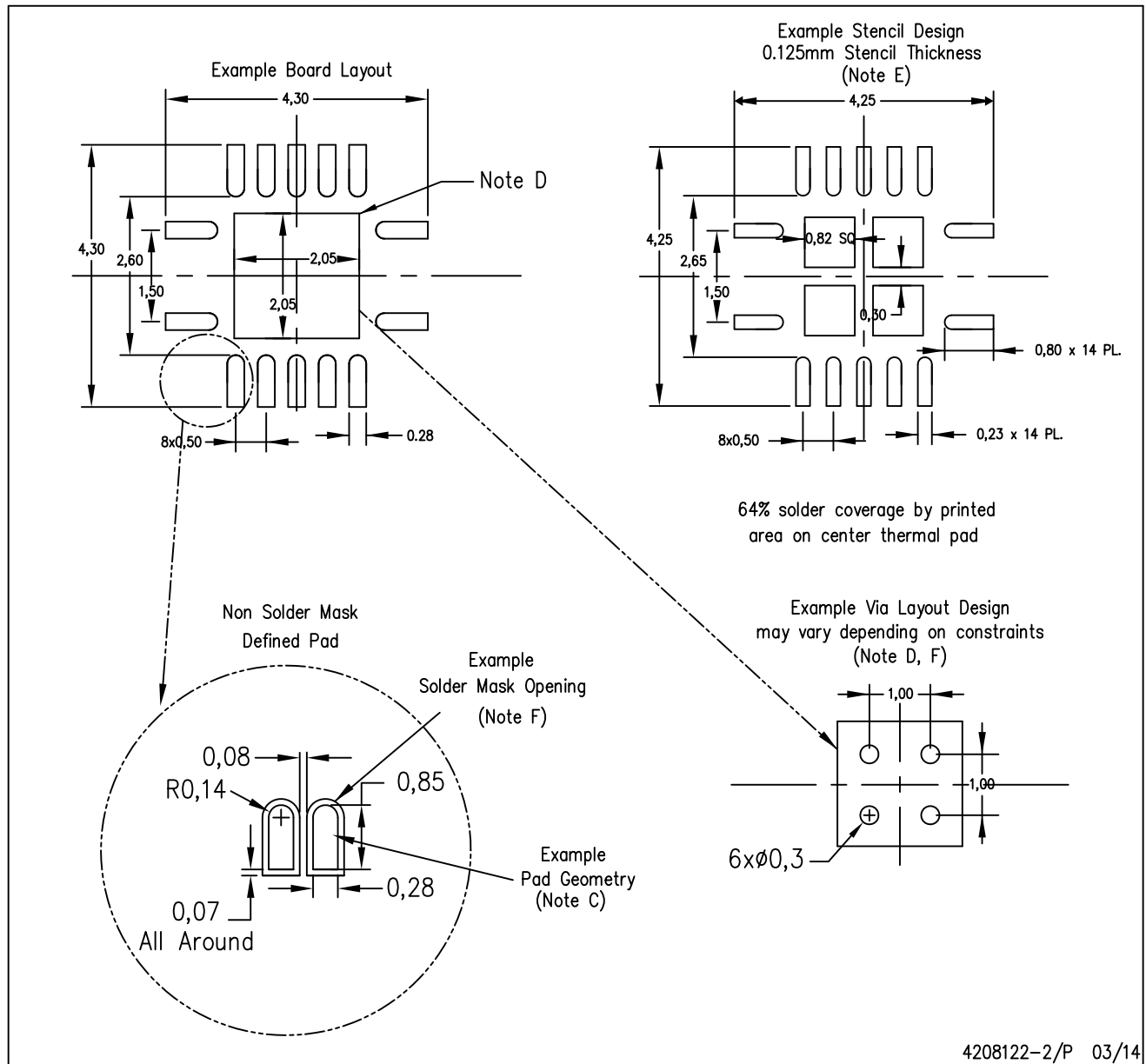
Exposed Thermal Pad Dimensions

4206353-2/P 03/14

NOTE: All linear dimensions are in millimeters

RGY (S-PVQFN-N14)

PLASTIC QUAD FLATPACK NO-LEAD



4208122-2/P 03/14

- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. Publication IPC-7351 is recommended for alternate designs.
  - D. This package is designed to be soldered to a thermal pad on the board. Refer to Application Note, Quad Flat-Pack QFN/SON PCB Attachment, Texas Instruments Literature No. 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>>.
  - E. 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.
  - F. Customers should contact their board fabrication site for minimum solder mask web tolerances between signal pads.

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