# A True 150-nA $I_Q$, 0.9-3.6$V_{IN}$, Selectable 1.8-5$V_{OUT}$ Instant-On™ Boost Converter

## FEATURES

- Ultra-Efficient Boost Converter:
  - Active Mode, No-load Supply Current: 150nA
  - Efficiency: Up to 92%
  - Input Voltage Range: 0.9V-3.6V
  - Delivers up to 35mA at 3$V_{STORE}$ from 1.2$V_{IN}$
  - Single-inductor, Discontinuous Conduction Mode Operation
  - No External Schottky Diode Required
- Pin-Selectable Output Voltages:
  - 1.8V, 2.1V, 2.5V, 2.85V, 3V, 3.3V, 4.1V, and 5V
- User-enabled Secondary Output Load Switch
- 10-Pin, Low-Profile, 2mm x 2mm TDFN Package

## APPLICATIONS

Coin Cell-Powered Portable Equipment
Single Cell Li-ion or Alkaline Powered Equipment
Solar or Mechanical Energy Harvesting
Wireless Microphones
Wireless Remote Sensors
RFID Tags
Blood Glucose Meters
Personal Health-Monitoring Devices
ZigBee Radio Enabled Devices
Low-Energy Bluetooth Radio Enabled Devices

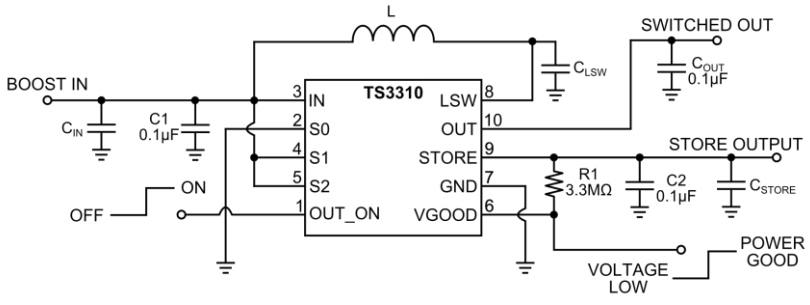
## DESCRIPTION

The TS3310 is a low power boost switching regulator with an industry leading low quiescent current of 150nA. The 150nA is the actual current consumed from the battery while the output is in regulation. The TS3310's extremely low power internal circuitry consumes 90nA on average, with periodic switching cycles which service the load occurring at intervals of up to 25 seconds, together yielding the average 150nA. The TS3310 steps up input voltages from 0.9V to 3.6V to eight selectable output voltages ranging from 1.8V to 5V. The TS3310 includes two output options, one being an always-on storage output while the additional output is an output load switch that is designed to supply burst-on loads in a low duty cycle manner. The TS3310 operates in Discontinuous Conduction Mode with an on-time proportional to 1/$V_{IN}$, thereby limiting the maximum input current by the selection of the inductor value, ensuring the input current does not drag down the input source.

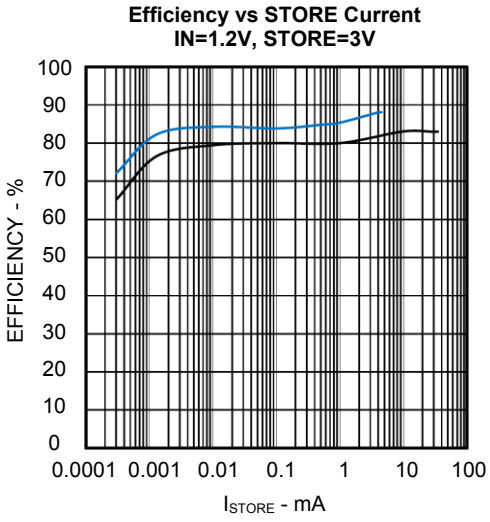
The extremely low quiescent current combined with the output load switch make the TS3310 an ideal choice for applications where the load can be periodically powered from the output, while being disconnected from the output storage capacitor when the load is powered off to isolate the load's leakage current.

The TS3310 is fully specified over the -40°C to +85°C temperature range and is available in a low-profile, thermally-enhanced 10-pin 2x2mm TDFN package with an exposed back-side paddle.

## TYPICAL APPLICATION CIRCUIT




| | Circuit A | Circuit B |
|---|---|---|
| L | 10µH<br>PN: CBC3225T100KR | 100µH<br>PN: CBC3225T101KR |
| $C_{IN}$ = $C_{STORE}$ | 10µF | 1µF |
| $C_{LSW}$ | 220pF | --- |



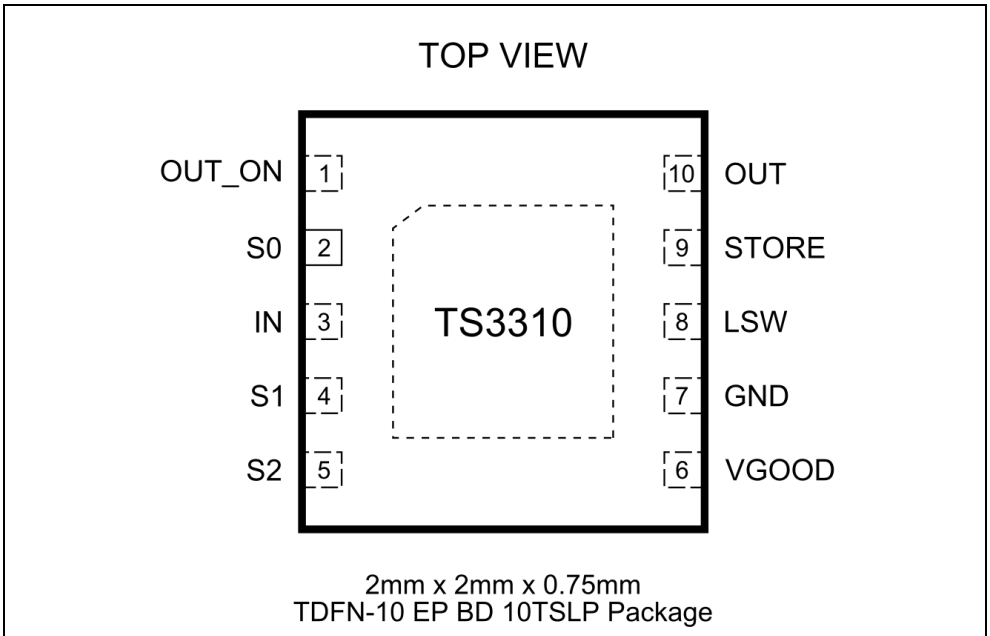
## ABSOLUTE MAXIMUM RATINGS

IN to GND ..... -0.3V to +6.0V
STORE to GND ..... -0.3V to +6.0V
OUT to GND ..... -0.3V to +6.0V
LSW to GND ..... -0.3V to +6.0V
OUT_ON, S0, S1, S2 to GND ..... -0.3V to +6.0V
VGOOD to GND ..... -0.3V to +6.0V

Continuous Power Dissipation ($T_A$ = +70°C)
10-Pin TDFN22EP (Derate at 13.48mW/°C above +70°C) 1078mW
Operating Temperature Range ..... -40°C to +85°C
Junction Temperature ..... +150°C
Storage Temperature Range ..... -65°C to +150°C
Lead Temperature (Soldering, 10s) ..... +300°C

Electrical and thermal 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 condition beyond those indicated in the operational sections of the specifications is not implied. Exposure to any absolute maximum rating conditions for extended periods may affect device reliability and lifetime.

## PACKAGE/ORDERING INFORMATION




2mm x 2mm x 0.75mm
TDFN-10 EP BD 10TSLP Package

| ORDER NUMBER | PART MARKING | CARRIER | QUANTITY |
|---|---|---|---|
| TS3310ITD1022 | AAW | TAPE & REEL | ----- |
| TS3310ITD1022T | | TAPE & REEL | 3000 |

**Lead-free Program:** Silicon Labs supplies only lead-free packaging.

Consult Silicon Labs for products specified with wider operating temperature ranges.

# ELECTRICAL CHARACTERISTICS

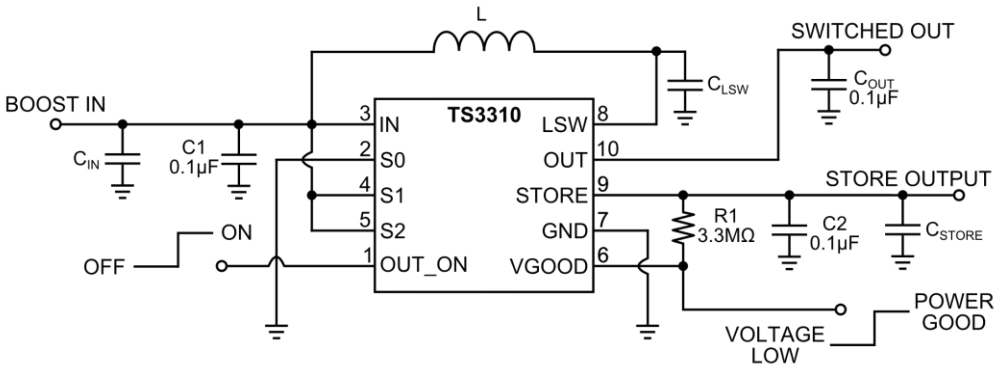
$V_{IN}$=1.2V, $V_{OUT\_ON}$=$V_{IN}$, VPROG is the programmed voltage according to S2, S1, S0 pins set for STORE voltage of 3V unless otherwise specified. $T_A$=-40°C to 85°C. Typical values are at $T_A$=+25°C unless otherwise specified. Please see Note 1.

| PARAMETER | | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|---|
| Input Voltage Range | | $V_{IN}$ | | 0.9 | | 3.6 | V |
| Under Voltage Lock Out | | UVLO | | | 0.855 | 0.9 | V |
| | | Hysteresis | | | 20 | | mV |
| STORE Voltage | | $V_{STORE}$ | $I_{STORE}$=50% of $I_{STORE(MAX)}$, 0.9V<VIN<3.6V, at any VPROG>VIN. TA=+25°C. See Note 2. | 0.97 x VPROG | VPROG | 1.03 x VPROG | V |
| VPROG Tempco | | | | | 0.027 | | % / °C |
| No-Load Input Current, $I_Q$ | | I-Floor | @ IN. See Note 3. | | 90 | 180 | nA |
| | | | @ STORE. See Note 3. | | 30 | | |
| | | Active-Mode | @ IN. See Note 4. | | 150 | | |
| Boost Switch On-Time | | $T_{ON}$ | $V_{IN}$=1.8V | 0.8 x 2/$V_{IN}$ | 2/$V_{IN}$ | 1.2 x 2/$V_{IN}$ | µsec |
| On Resistance | NMOS | $R_{ON}$ NMOS | $V_{STORE}$=1.8V | | 0.8 | 1.3 | Ω |
| | PMOS | $R_{ON}$ PMOS | | | 1.1 | 1.65 | |
| | LOAD SWITCH | $R_{ON}$ LOAD SWITCH | | | 1.1 | 1.65 | |
| | NMOS | $R_{ON}$ NMOS | $V_{STORE}$=3V | | 500 | | mΩ |
| | PMOS | $R_{ON}$ PMOS | | | 650 | | |
| | LOAD SWITCH | $R_{ON}$ LOAD SWITCH | | | 650 | | |
| VSTORE GOOD | | $V_{VGOOD}$ | % of target STORE voltage | 80 | 90 | 95 | % |
| | | Hysteresis | | | 5 | | |
| $V_{OUT\_ON}$ Input Voltage | | $V_{OUT\_ON\ L}$ | Low CMOS Logic Level | | | 0.2 | V |
| | | $V_{OUT\_ON\ H}$ | High CMOS Logic Level | 0.6 | | | |
| S0, S1, S2 Input Voltage | | S0L, S1L, S2L | Low CMOS Logic Level | | | 0.2 | V |
| | | S0H, S1H, S2H | High CMOS Logic Level | 0.6 | | | |
| S0, S1, S2, OUT_ON Input Leakage Current | | | | | 5 | | nA |

**Note 1:** All devices are 100% production tested at $T_A$ = +25°C and are guaranteed by characterization for $T_A$ = -40°C to +85°C, as specified.
**Note 2:** $I_{STORE(MAX)}$ is provided as the Maximum Average STORE Current by the graph entitled “Expected Maximum STORE Output Current” in the TS3310 Applications Section.
**Note 3:** $V_{STORE}$ output is driven above regulation point. No switching is occurring.
**Note 4**: $V_{STORE}$=3V. L=100µH. $C_{STORE}$=1µF.

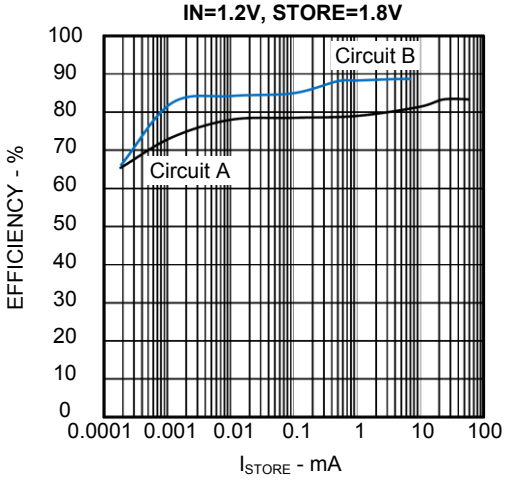
# TYPICAL PERFORMANCE CHARACTERISTICS

$V_{OUT\_ON}$=GND, $V_{VGOOD}$=GND, $C_{OUT}$=C1=C2=0.1µF, $I_{STORE}$=0A, $I_{OUT}$=0A unless otherwise specified. Values are at $T_A$=25°C unless otherwise specified.

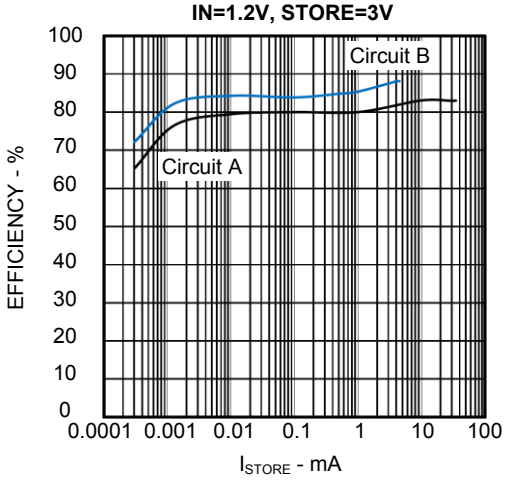



| | Circuit A | Circuit B |
|---|---|---|
| **L** | 10µH<br>PN: CBC3225T100KR | 100µH<br>PN: CBC3225T101KR |
| **$C_{IN}$=$C_{STORE}$** | 10µF | 1µF |
| **$C_{LSW}$** | 220pF | --- |

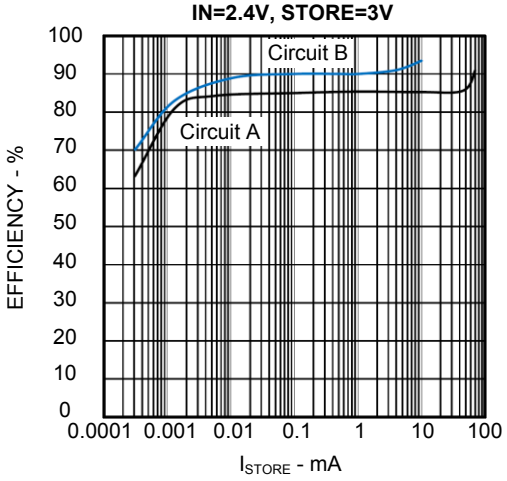
**Efficiency vs STORE Output Current**
**IN=1.2V, STORE=1.8V**



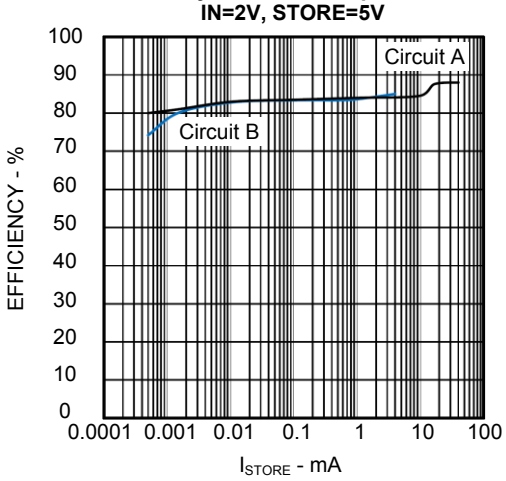

**Efficiency vs STORE Output Current**
**IN=1.2V, STORE=3V**




**Efficiency vs STORE Output Current**
**IN=2.4V, STORE=3V**

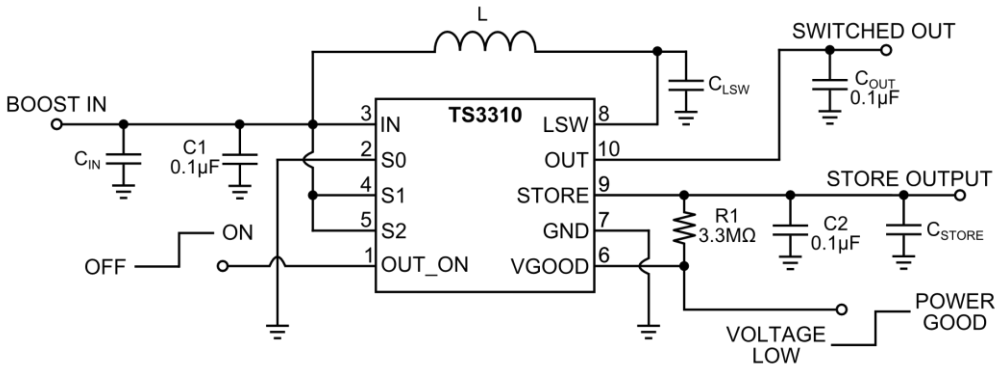



**Efficiency vs STORE Output Current**
**IN=2V, STORE=5V**



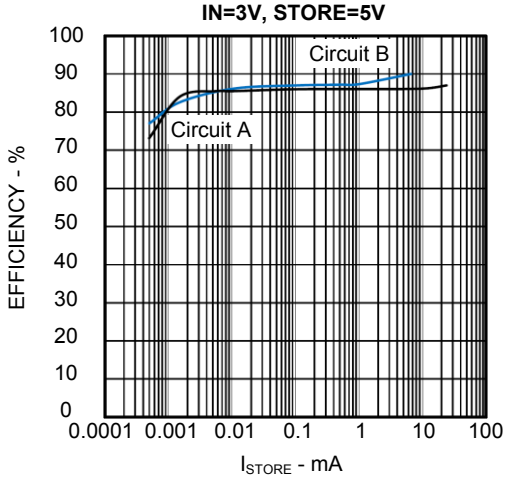
# TYPICAL PERFORMANCE CHARACTERISTICS

$V_{OUT\_ON}$=GND, $V_{VGOOD}$=GND, $C_{OUT}$=C1=C2=0.1µF, $I_{STORE}$=0A, $I_{OUT}$=0A unless otherwise specified. Values are at $T_A$=25°C unless otherwise specified.

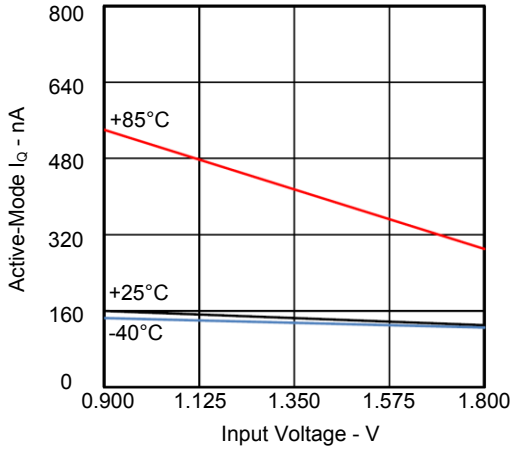



| | Circuit A | Circuit B |
|---|---|---|
| **L** | 10µH<br>PN: CBC3225T100KR | 100µH<br>PN: CBC3225T101KR |
| **$C_{IN}$=$C_{STORE}$** | 10µF | 1µF |
| **$C_{LSW}$** | 220pF | --- |

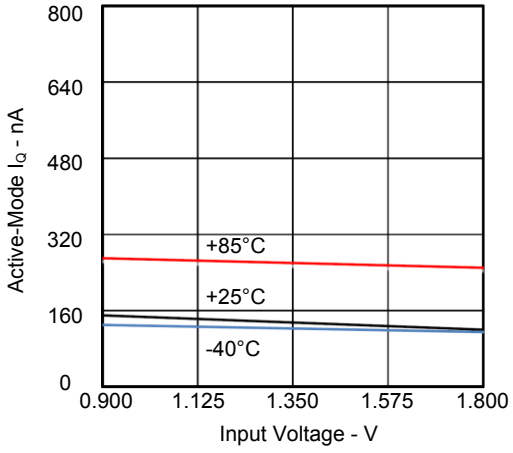
**Efficiency vs STORE Output Current**
**IN=3V, STORE=5V**




**Active-Mode $I_Q$ vs Input Voltage with No Load : Circuit A (STORE=1.8V)**

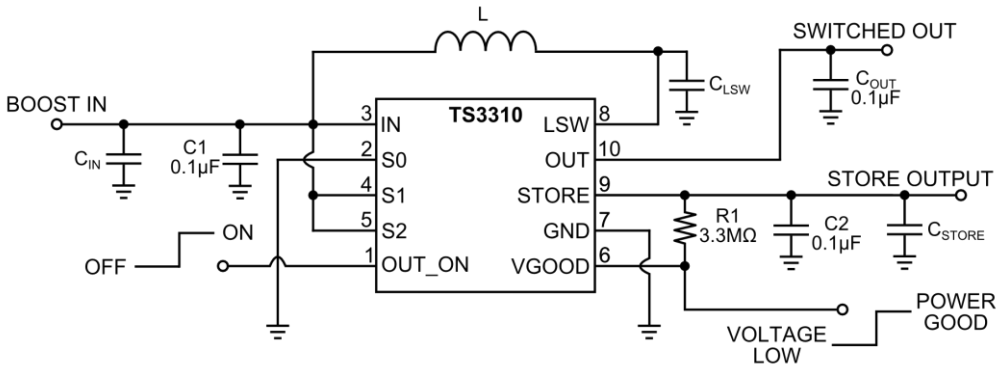



**Active-Mode $I_Q$ vs Input Voltage with No Load : Circuit B (STORE=1.8V)**



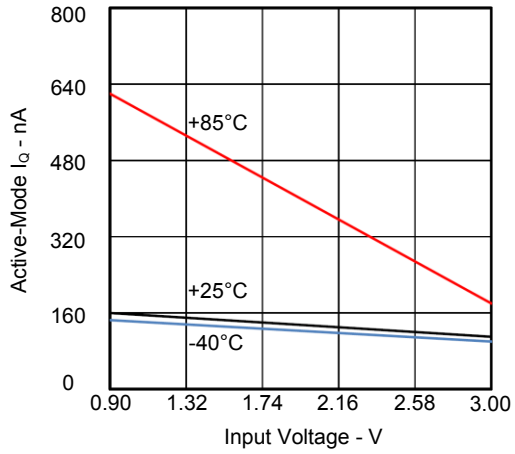
# TYPICAL PERFORMANCE CHARACTERISTICS

$V_{OUT\_ON}$=GND, $V_{VGOOD}$=GND, $C_{OUT}$=C1=C2=0.1µF, $I_{STORE}$=0A, $I_{OUT}$=0A unless otherwise specified. Values are at $T_A$=25°C unless otherwise specified.

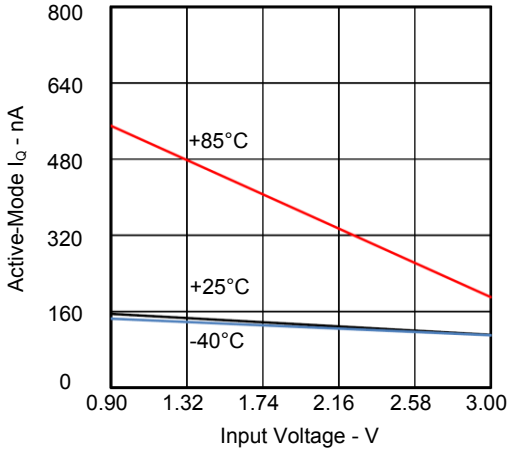



| | Circuit A | Circuit B |
|---|---|---|
| **L** | 10µH<br>PN: CBC3225T100KR | 100µH<br>PN: CBC3225T101KR |
| **$C_{IN}$=$C_{STORE}$** | 10µF | 1µF |
| **$C_{LSW}$** | 220pF | --- |

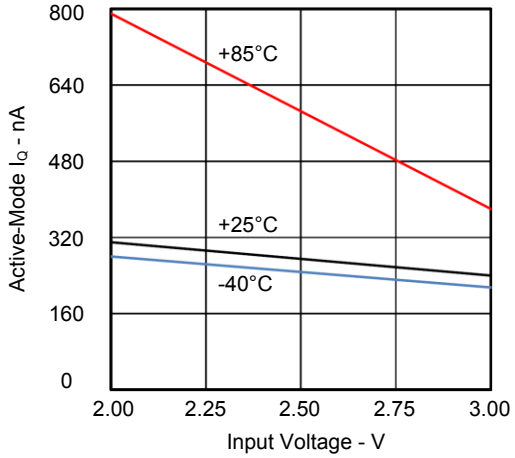
**Active-Mode $I_Q$ vs Input Voltage with No Load : Circuit A (STORE=3V)**



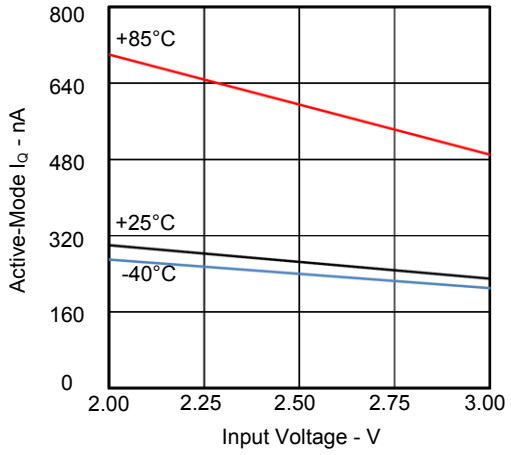

**Active-Mode $I_Q$ vs Input Voltage with No Load : Circuit B (STORE=3V)**




**Active-Mode $I_Q$ vs Input Voltage with No Load : Circuit A (STORE=5V)**

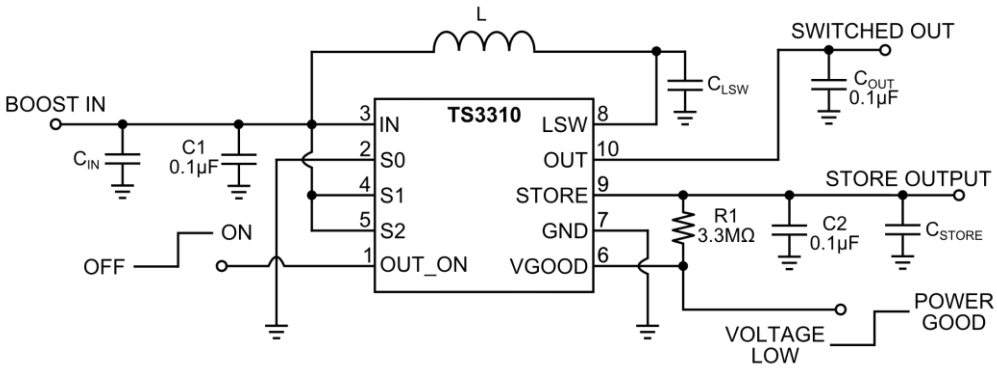



**Active-Mode $I_Q$ vs Input Voltage with No Load : Circuit B (STORE=5V)**



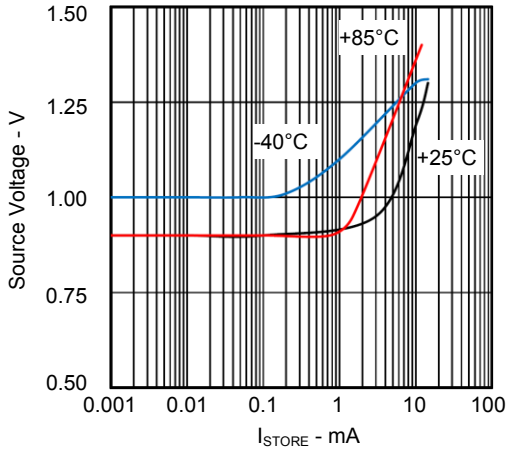
# TYPICAL PERFORMANCE CHARACTERISTICS

$V_{OUT\_ON}$=GND, $V_{VGOOD}$=GND, $C_{OUT}$=C1=C2=0.1µF, $I_{STORE}$=0A, $I_{OUT}$=0A unless otherwise specified. Values are at $T_A$=25°C unless otherwise specified.

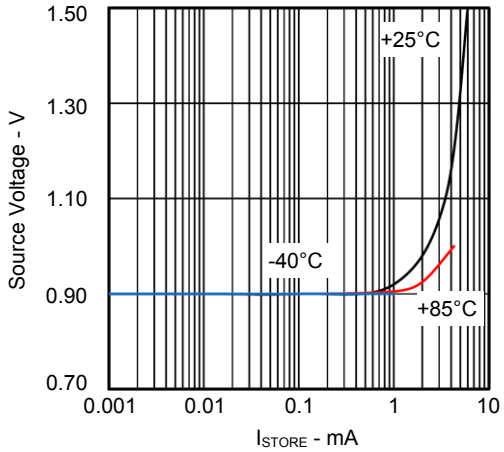



| | Circuit A | Circuit B |
|---|---|---|
| **L** | 10µH<br>PN: CBC3225T100KR | 100µH<br>PN: CBC3225T101KR |
| **$C_{IN}$=$C_{STORE}$** | 10µF | 1µF |
| **$C_{LSW}$** | 220pF | --- |

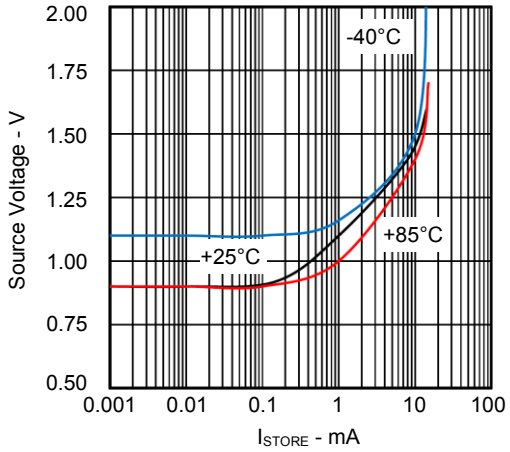
**Minimum Start-Up Voltage vs STORE Output Current**
**Circuit A with 10Ω Source Resistance (STORE=1.8V)**



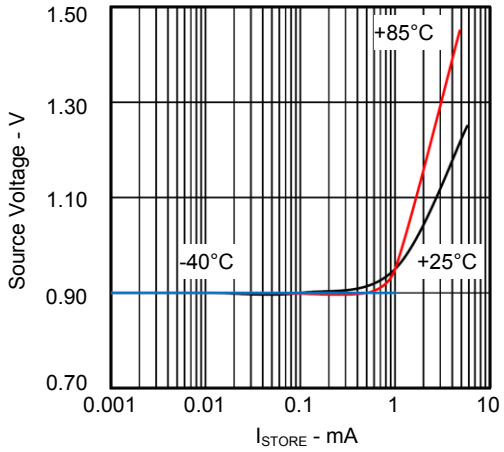

**Minimum Start-Up Voltage vs STORE Output Current**
**Circuit B with 10Ω Source Resistance (STORE=1.8V)**




**Minimum Start-Up Voltage vs STORE Output Current**
**Circuit A with 10Ω Source Resistance (STORE=3V)**

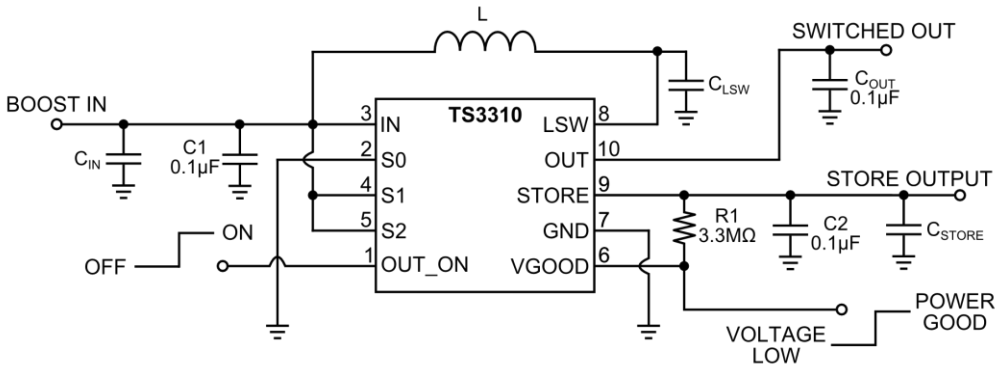



**Minimum Start-Up Voltage vs STORE Output Current**
**Circuit B with 10Ω Source Resistance (STORE=3V)**



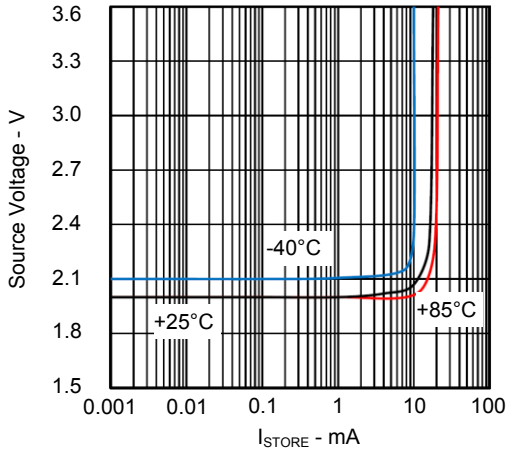
# TYPICAL PERFORMANCE CHARACTERISTICS

$V_{OUT\_ON}$=GND, $V_{VGOOD}$=GND, $C_{OUT}$=C1=C2=0.1µF, $I_{STORE}$=0A, $I_{OUT}$=0A unless otherwise specified. Values are at $T_A$=25°C unless otherwise specified.

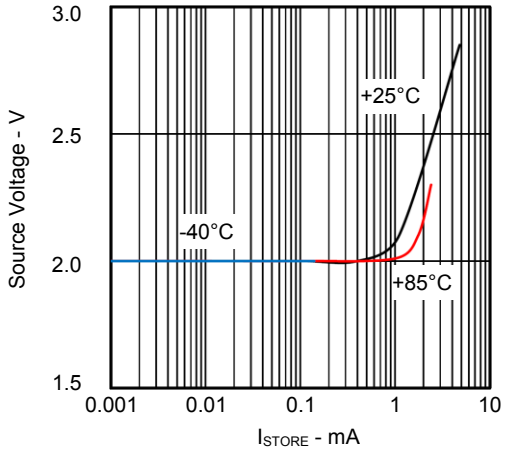



| | Circuit A | Circuit B |
|---|---|---|
| **L** | 10µH<br>PN: CBC3225T100KR | 100µH<br>PN: CBC3225T101KR |
| **$C_{IN}$=$C_{STORE}$** | 10µF | 1µF |
| **$C_{LSW}$** | 220pF | --- |

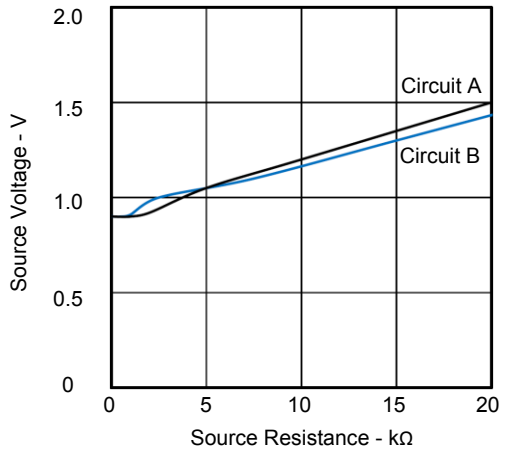
**Minimum Start-Up Voltage vs STORE Output Current**
**Circuit A with 10Ω Source Resistance (STORE=5V)**



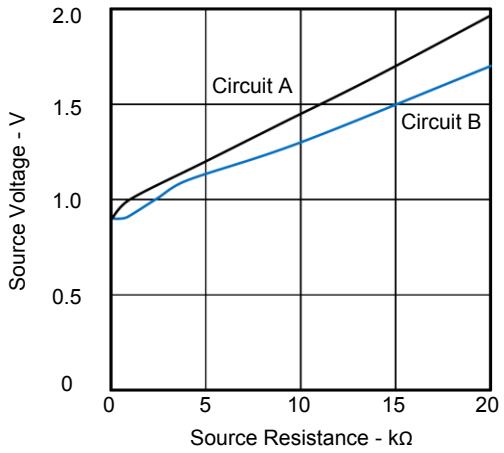

**Minimum Start-Up Voltage vs STORE Output Current**
**Circuit B with 10Ω Source Resistance (STORE=5V)**




**Minimum Start-Up Voltage**
**vs Source Resistance : $V_{STORE}$=1.8V**

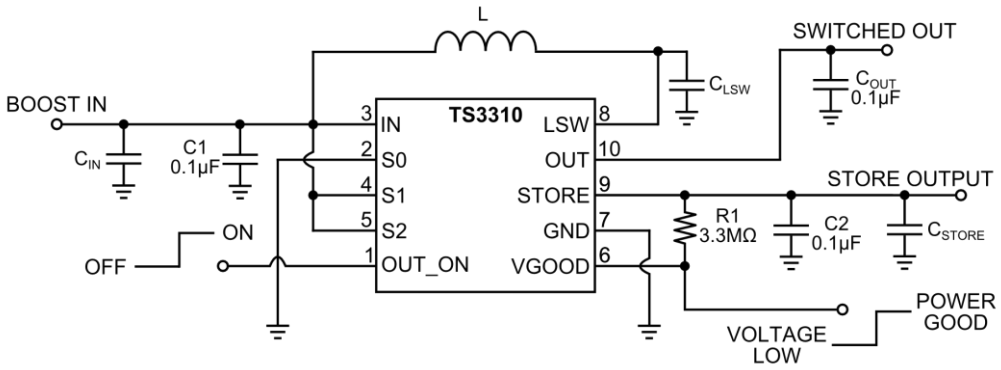



**Minimum Start-Up Voltage**
**vs Source Resistance : $V_{STORE}$=3V**



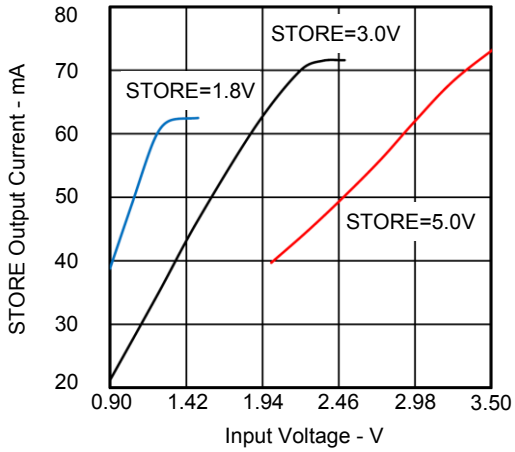
# TYPICAL PERFORMANCE CHARACTERISTICS

$V_{OUT\_ON}$=GND, $V_{VGOOD}$=GND, $C_{OUT}$=C1=C2=0.1µF, $I_{STORE}$=0A, $I_{OUT}$=0A unless otherwise specified. Values are at $T_A$=25°C unless otherwise specified.

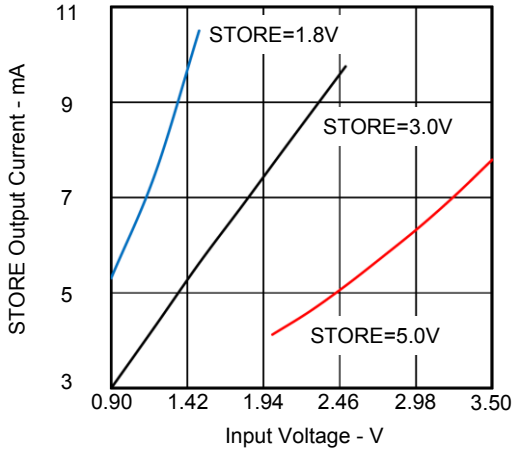



| | Circuit A | Circuit B |
|---|---|---|
| **L** | 10µH<br>PN: CBC3225T100KR | 100µH<br>PN: CBC3225T101KR |
| **$C_{IN}$=$C_{STORE}$** | 10µF | 1µF |
| **$C_{LSW}$** | 220pF | --- |

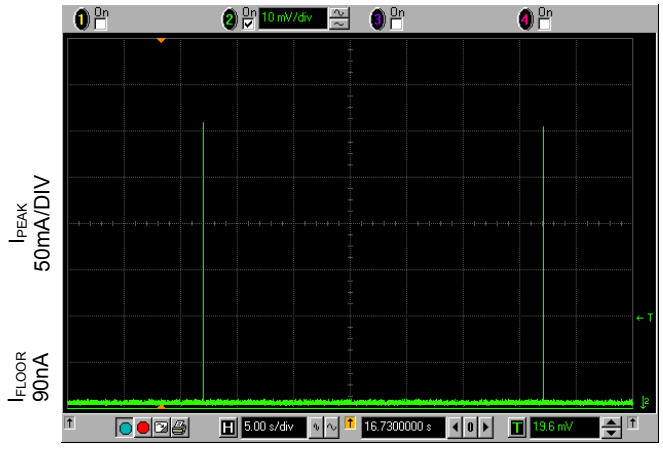
**Maximum STORE Output Current vs Input Voltage w/ $V_{STORE}$ ≥ 96% of Target Voltage : Circuit A**




**Maximum STORE Output Current vs Input Voltage w/ $V_{STORE}$ ≥ 96% of Target Voltage : Circuit B**

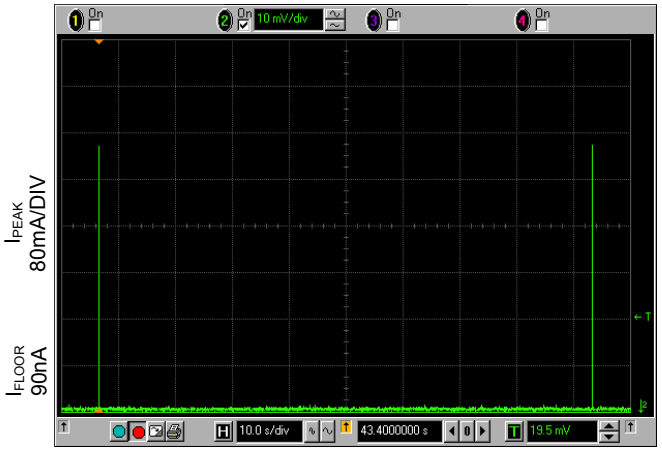



**Active-Mode $I_Q$ : Circuit A with No-Load $V_{IN}$=1.2V, STORE=3V**




5 s/DIV

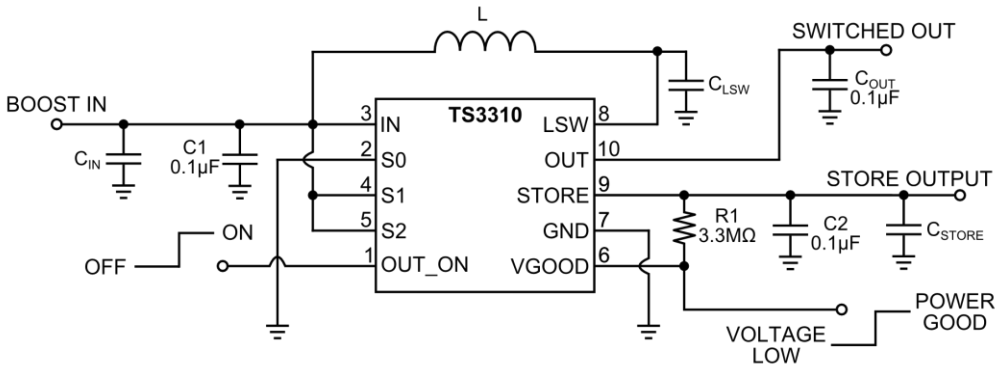
**Active-Mode $I_Q$ : Circuit A with No-Load $V_{IN}$=3V, STORE=3V**




10 s/DIV

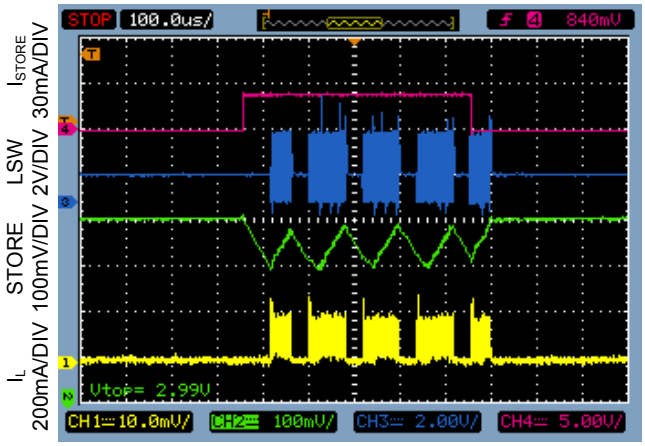
# TYPICAL PERFORMANCE CHARACTERISTICS

$V_{OUT\_ON}$=GND, $V_{VGOOD}$=GND, $C_{OUT}$=C1=C2=0.1µF, $I_{STORE}$=0A, $I_{OUT}$=0A unless otherwise specified. Values are at $T_A$=25°C unless otherwise specified.

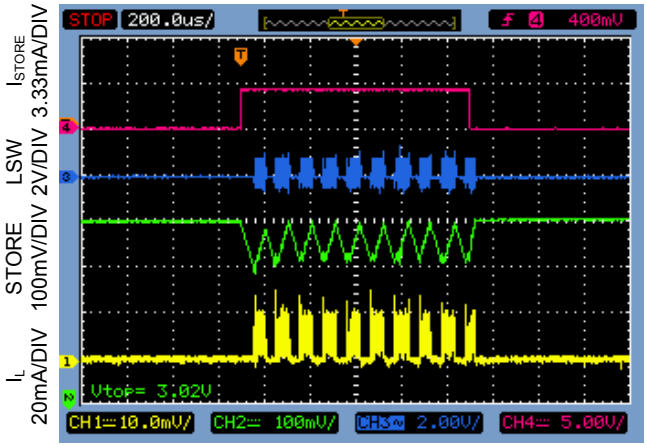



| | Circuit A | Circuit B |
|---|---|---|
| **L** | 10µH<br>PN: CBC3225T100KR | 100µH<br>PN: CBC3225T101KR |
| **$C_{IN}$=$C_{STORE}$** | 10µF | 1µF |
| **$C_{LSW}$** | 220pF | --- |

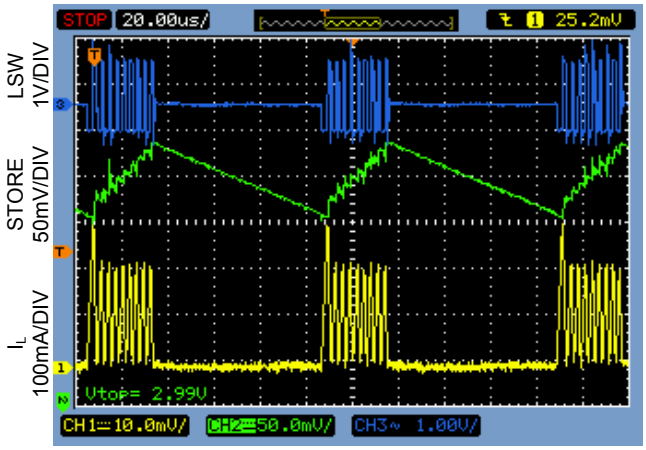
**STORE Load Step Response : Circuit A**
**$V_{IN}$=1.2V, STORE=3V, $I_{STORE}$=24mA**



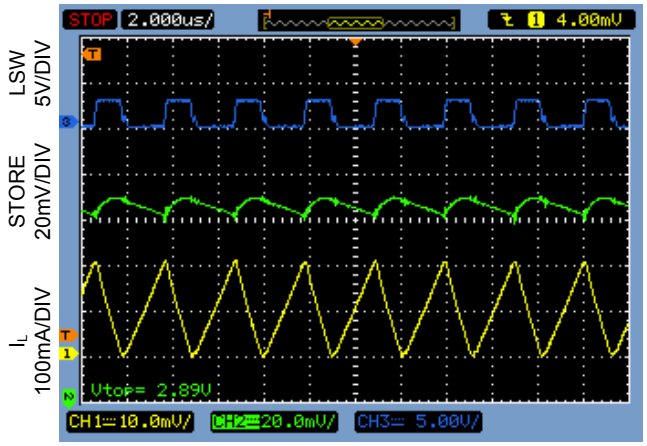

**STORE Load Step Response : Circuit B**
**$V_{IN}$=1.2V, STORE=3V, $I_{STORE}$=3mA**




**STORE Output Voltage Ripple, Inductor Current, and LSW Voltage : Circuit A**
**$V_{IN}$=1.2V, STORE=3V, $I_{STORE}$=10mA**

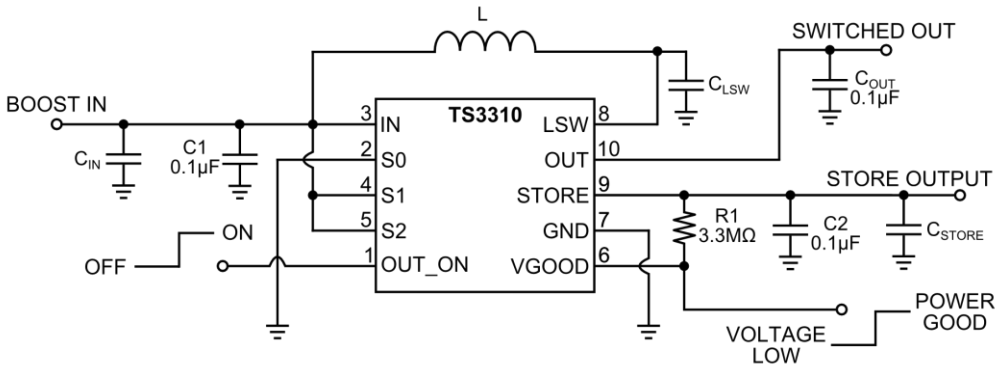



**STORE Output Voltage Ripple, Inductor Current, and LSW Voltage : Circuit A**
**$V_{IN}$=1.2V, STORE=3V, $I_{STORE(MAX)}$=35mA**



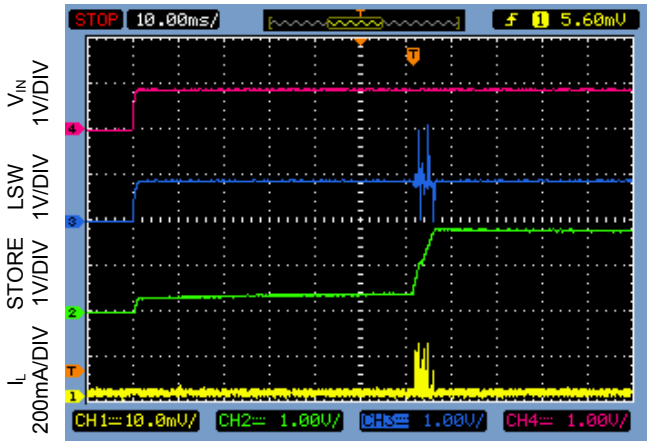
# TYPICAL PERFORMANCE CHARACTERISTICS

$V_{OUT\_ON}$=GND, $V_{VGOOD}$=GND, $C_{OUT}$=C1=C2=0.1µF, $I_{STORE}$=0A, $I_{OUT}$=0A unless otherwise specified. Values are at $T_A$=25°C unless otherwise specified.

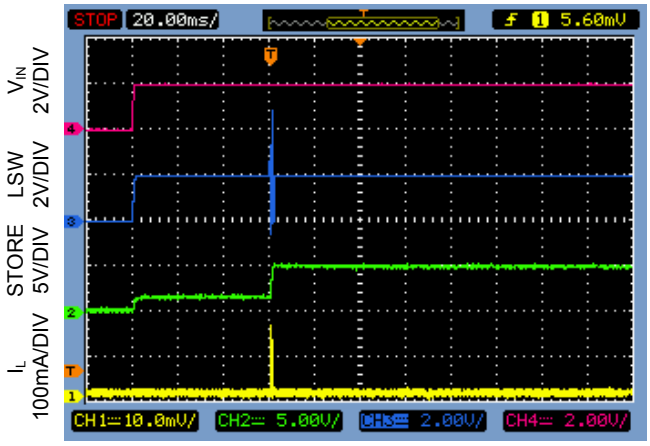



| | Circuit A | Circuit B |
|---|---|---|
| **L** | 10µH<br>PN: CBC3225T100KR | 100µH<br>PN: CBC3225T101KR |
| **$C_{IN}$=$C_{STORE}$** | 10µF | 1µF |
| **$C_{LSW}$** | 220pF | --- |

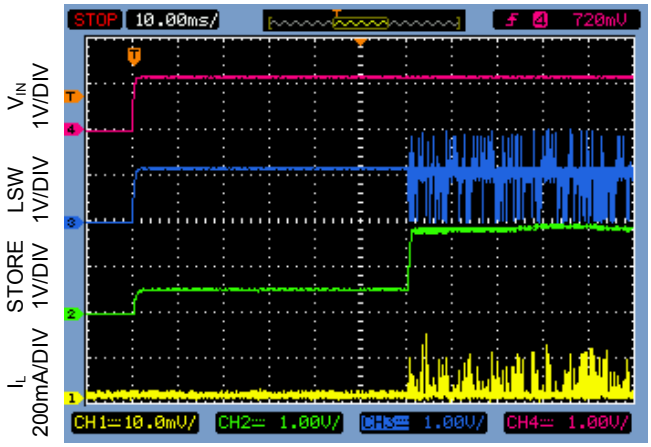
**Startup : Circuit A with $R_{IN}$=10Ω**
**$V_{IN}$=0.9V, STORE=1.8V, $I_{STORE}$=0.18µA**



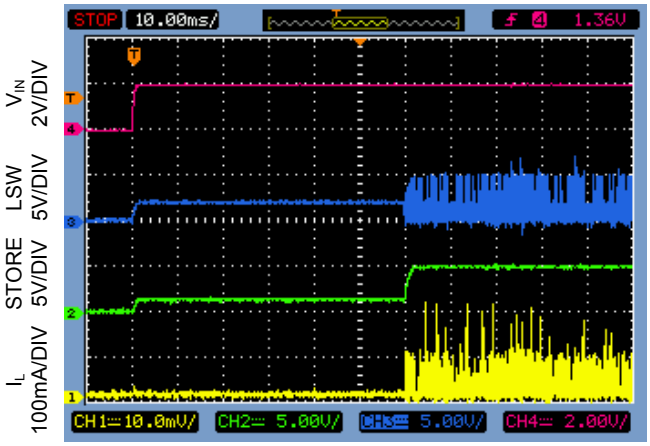

**Startup : Circuit A with $R_{IN}$=10Ω**
**$V_{IN}$=2V, STORE=5V, $I_{STORE}$=0.5µA**




**Startup : Circuit A with $R_{IN}$=10Ω**
**$V_{IN}$=1.2V, STORE=1.8V, $I_{STORE}$=10mA**

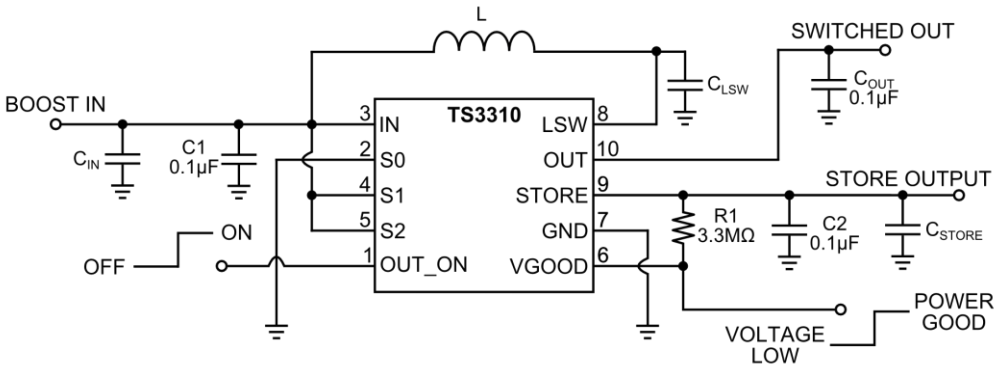



**Startup : Circuit A with $R_{IN}$=10Ω**
**$V_{IN}$=2V, STORE=5V, $I_{STORE}$=10mA**



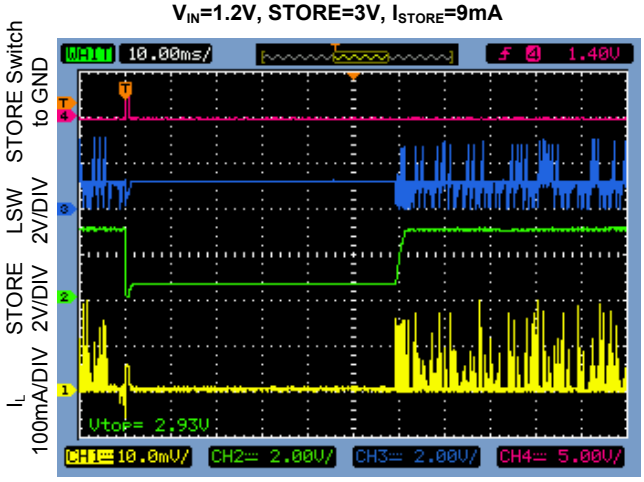
# TYPICAL PERFORMANCE CHARACTERISTICS

$V_{OUT\_ON}$=GND, $V_{VGOOD}$=GND, $C_{OUT}$=C1=C2=0.1µF, $I_{STORE}$=0A, $I_{OUT}$=0A unless otherwise specified. Values are at $T_A$=25°C unless otherwise specified.

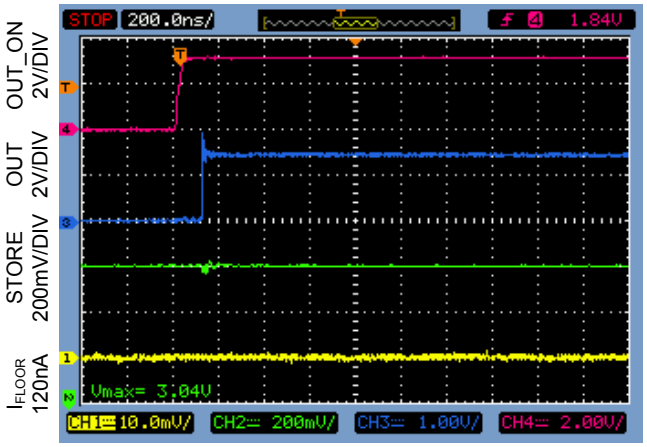



| | Circuit A | Circuit B |
|---|---|---|
| **L** | 10µH<br>PN: CBC3225T100KR | 100µH<br>PN: CBC3225T101KR |
| **$C_{IN}$=$C_{STORE}$** | 10µF | 1µF |
| **$C_{LSW}$** | 220pF | --- |

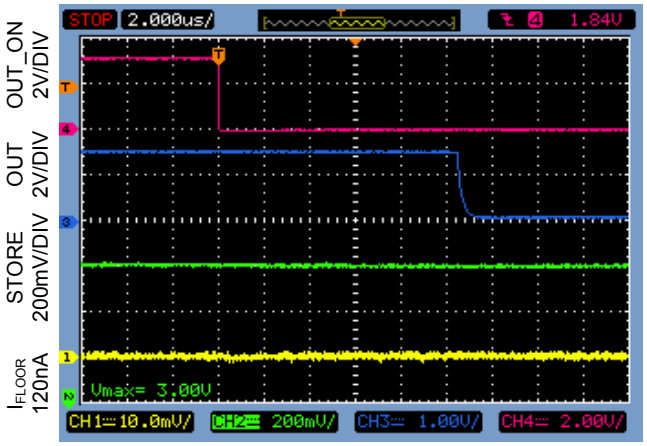
**Short STORE to GND for 1msec Recovery : Circuit A**
**$V_{IN}$=1.2V, STORE=3V, $I_{STORE}$=9mA**




**OUT_ON Switched ON : Circuit A with $C_{OUT}$ Removed**
**$V_{IN}$=1.2V, STORE=3V, $I_{STORE}$=0.3µA, $I_{OUT}$=3mA**



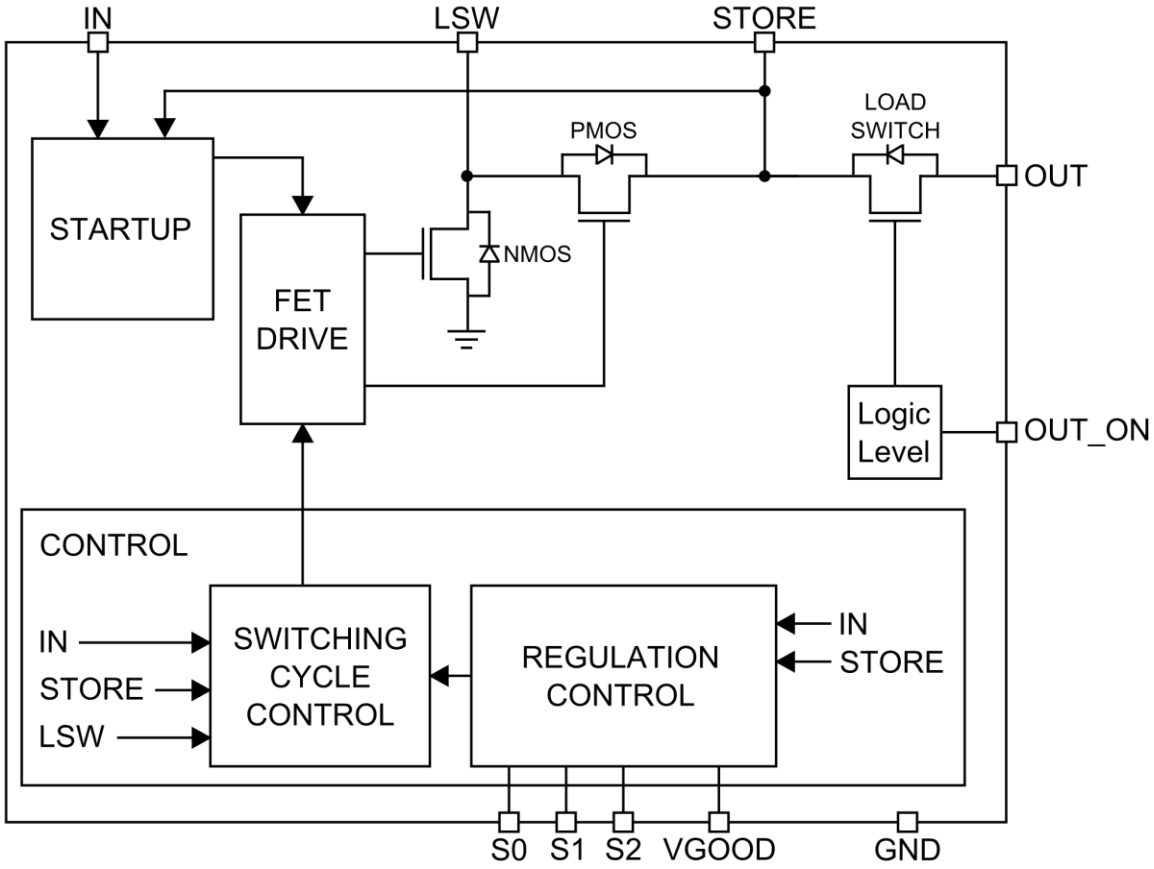

**OUT_ON Switched OFF : Circuit A with $C_{OUT}$ Removed**
**$V_{IN}$=1.2V, STORE=3V, $I_{STORE}$=0.3µA, $I_{OUT}$=3mA**



## PIN FUNCTIONS

| PIN | NAME | FUNCTION |
|---|---|---|
| 1 | OUT_ON | Logic Input. Turns on OUT switch. |
| 2 | S0 | Logic Input. Sets the regulated voltage at STORE. |
| 3 | IN | Boost Input. Connect to input source. Connect Input capacitor, $C_{IN}$. |
| 4 | S1 | Logic Input. Sets the regulated voltage at STORE. |
| 5 | S2 | Logic Input. Sets the regulated voltage at STORE. |
| 6 | VGOOD | Open Drain Output. High impedance when STORE>90% of regulation voltage. |
| 7 | GND | Ground. Connect this pin to the analog ground plane. |
| 8 | LSW | Inductor Connection. If using an inductor value ≤22µH, please see Table 3 for recommended $C_{LSW}$ values. |
| 9 | STORE | Regulated output voltage set by S0, S1, S2 logic. Connect Storage capacitor, $C_{STORE}$. |
| 10 | OUT | Switched Output. |
| Exposed Paddle | EP | For best electrical and thermal performance, connect exposed backside paddle to analog ground plane. |

## BLOCK DIAGRAM



# THEORY OF OPERATION

The TS3310 is a boost switching regulator with an industry leading low quiescent current of 150nA.The 150nA is the actual current consumed from the battery while the output is in regulation. The TS3310's extremely low power internal circuitry consumes 90nA on average, with periodic switching cycles which service the load occurring at intervals of up to 25 seconds, as displayed in the scope capture entitled "Input Quiescent Current : Circuit A with No-Load" on Page 9. The always-on output voltage at STORE is regulated by a comparator within the Regulation Control block. When a load discharges $C_{STORE}$ and causes the output voltage to drop below the desired regulated voltage, switching periods are initiated. When the output voltage is at or above the desired regulated voltage, the comparator causes switching periods to stop.

Each switching cycle includes an ON period and an OFF period. During the ON period, the NMOS switch turns on to ramp current in the inductor, while during the OFF period, the NMOS switch turns off and the PMOS switch turns on to discharge inductor current into the $C_{STORE}$ capacitor. When the ON and OFF cycles have completed, the PMOS switch turns off. The TS3310 operates in Discontinuous Conduction Mode (DCM); during any given switching cycle, the inductor current starts at and returns to zero. The switching cycle timing is governed by the Control block, which determines the ON and OFF periods according to the input and output voltages, regardless of the inductor current. The Control block sets the ON period according to:

$$t_{ON} = \frac{2\mu s \cdot V}{V_{IN}}$$

**Equation 1.** ON Period Calculation

The choice of the inductor value, then, determines the peak switching currents:

$$I_{pk} = \frac{V_{IN} \times t_{ON}}{L} = \frac{2\mu s \cdot V}{L}$$

**Equation 2.** Peak-Current Calculation

The average input current, $I_{IN(AVG)}$, will vary according to the load, since as the load is increased, the time between switching cycles is decreased. However, $I_{IN(AVG)}$ will never exceed $I_{IN(AVG,MAX)}$, the maximum averaged input current, which represents the case where switching periods are continuously initiated.

$$I_{IN(AVG,MAX)} = \frac{I_{pk}}{2} = \frac{1\mu s \cdot V}{L}$$

**Equation 3.** Maximum Average Input Current Calculation

Equation 3 shows that an input current limit can be set by choice of inductor value, set appropriately for the capacity and output impedance of the input source.

Maximum available output current is also a function of inductor value for the case where switching cycles are continuously initiated, the expected maximum STORE output current is:

$$I_{STORE(MAX)} = \frac{V_{IN}}{V_{OUT}} \times I_{IN(AVG,MAX)} \times Eff$$

**Equation 4.** Expected Maximum STORE Current Calculation

The Regulation Controls within the Control block monitor and control the regulation of the STORE output voltage. By strapping a combination of logic input pins (S0-S2) high or low, the STORE output voltage can be one of 8 selectable output voltages. For 5V STORE output operation, a minimum $V_{IN}$ of 2V is required.

| S2 | S1 | S0 | STORE |
|---|---|---|---|
| 0 | 0 | 0 | 1.8V |
| 0 | 0 | 1 | 2.5V |
| 0 | 1 | 0 | 3.3V |
| 0 | 1 | 1 | 5.0V |
| 1 | 0 | 0 | 2.1V |
| 1 | 0 | 1 | 2.85V |
| 1 | 1 | 0 | 3.0V |
| 1 | 1 | 1 | 4.1V |

**Table 1.** STORE Output Voltage Options

The TS3310 provides an additional Instant-On switched OUT output that completely isolates loads from the storage capacitor at the STORE output. The OUT load switch is controlled by the logic input pin OUT_ON.

The TS3310 provides an Open-Drain VGOOD output that assumes a high impedance once the STORE output is greater than 90% of the target voltage.

The TS3310 comes with an Under Voltage Lockout (UVLO) feature at 0.855V with a 20mV hysteresis. The UVLO feature monitors the input voltage and inhibits the Switching Cycle Controls from initiating switching cycles if the $V_{IN}$ is too low. This ensures no switching currents are drawn from the input to collapse the voltage at the terminals of the battery when the internal resistance of the battery is high. Figure 1 displays the UVLO feature for the TS3310.

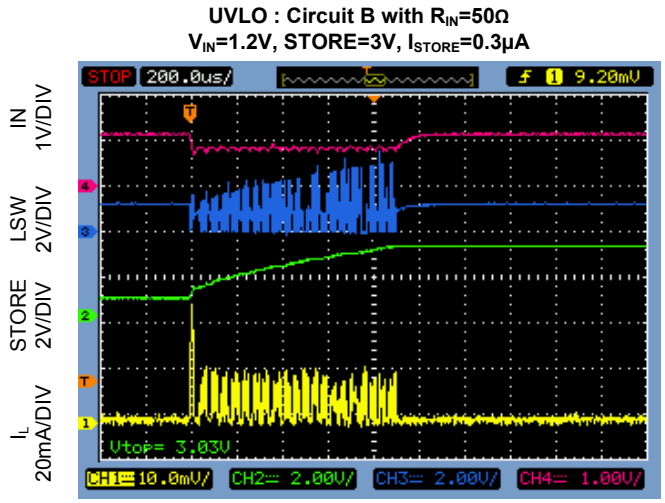



**Figure 1.** TS3310, UVLO=0.855V

# APPLICATIONS INFORMATION

### Inductor Selection

When selecting an inductor value, the value should be chosen based on output current requirements. If the input source is a small battery, make sure the choice of the inductor value considers the maximum input current that the source battery can support (based on series resistance). For example, some small button cell batteries can exhibit 5Ω series resistance, therefore a 20mA maximum input current may be appropriate (100mV drop). Consider using a large STORE capacitor to support peak loads for small batteries – see section “Bursted Load with Big Store Buffer Capacitor”.

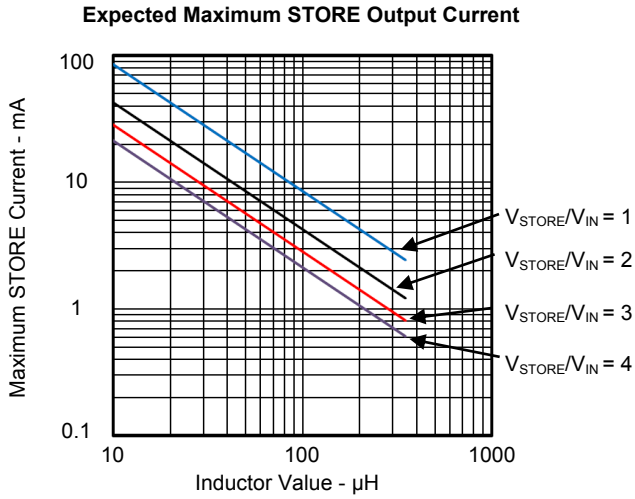



**Figure 2.** Expected Maximum STORE Output Current with 85% Efficiency vs Inductor Value

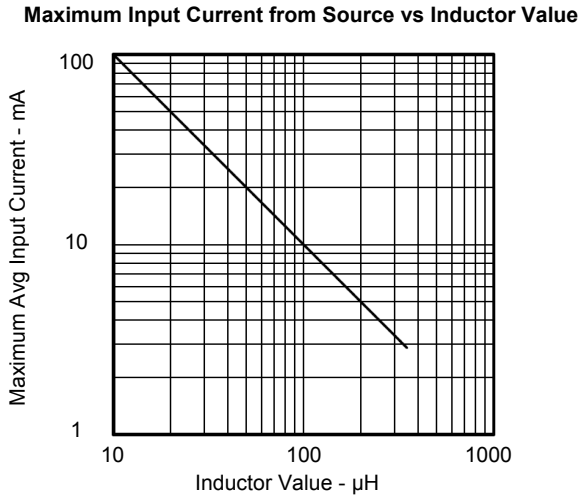



**Figure 3.** $I_{IN(AVG,MAX)}$ vs Inductor Value

A low ESR, shielded inductor is recommended. Depending upon the application, the inductor value will vary. For applications with load currents less than a few milliamperes, a 100µH inductor is recommended. As shown in the Efficiency Curves on Pages 4 and 5, the efficiency is greater with a larger inductor value for smaller load currents. Please refer to the two ‘Maximum Store Current vs Input Voltage’ graphs found on Page 9. Circuit A which uses a 10µH inductor is able to source larger load currents than that of Circuit B with a 100µH inductor due to the larger peak currents.

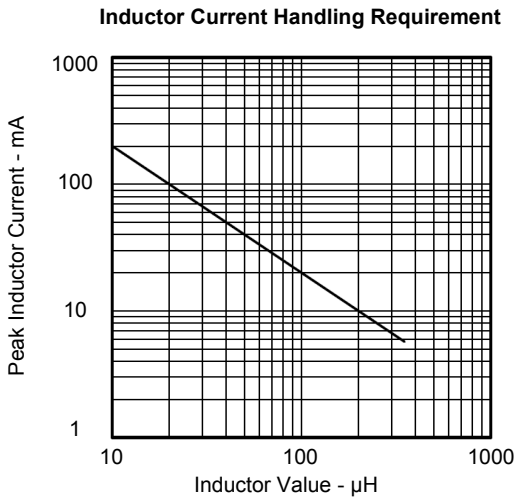



**Figure 4.** Inductor Peak Current vs Inductor Value

The chosen inductor's saturation current for a specific inductor value should be at least 50% greater than the peak inductor current value displayed in Figure 4, entitled 'Inductor Current Handling Requirements'. Table 2 provides a list of some inductor manufacturers.

| Inductors | |
|---|---|
| Taiyo Yuden | www.t-yuden.com |
| Murata | www.murata.com |
| Coilcraft | www.coilcraft.com |
| Sumida | www.sumida.com |

**Table 2.** Inductor Manufacturers

Tables 4 and 5 show some example inductors for values of 10µH and 100µH that may be used for circuit A or B. The tables include the inductors' $R_{dc}$ (inductor series dc resistance or ESR), saturation current, and dimensions. As mentioned previously, the inductor's saturation current should always be greater than 150% of the peak inductor current; therefore the appropriate size and efficiency (dependent upon ESR) may be chosen based on the application's requirements.

To guarantee maximum output power for 10µH and 22µH operation, a $C_{LSW}$ capacitor should be placed at the LSW pin to ground. Please refer to Table 3 for the recommended $C_{LSW}$ values. A ceramic capacitor with a NPO or COG dielectric is recommended for $C_{LSW}$ with a minimum voltage rating of 50V.

| Inductor Value | $C_{LSW}$ |
|---|---|
| >22µH | --- |
| 22µH | 100pF |
| 10µH | 220pF |

**Table 3.** Recommended $C_{LSW}$ Values

| Inductor Value P/N | Inductor Type | $R_{dc}$ | Saturation Current | (LxWxH) (mm) |
|---|---|---|---|---|
| 10µH CBC20166T100K | CBC 2016 | 0.82 Ω | 380mA | 2x1.6x1.6 |
| 10µH CBC2518T100K | CBC 2518 | 0.36 Ω | 480mA | 2.5x1.8x1.8 |
| 10µH CBC3225T100KR | CBC 3225 | 0.133 Ω | 900mA | 3.2x2.5x2.5 |
| 100µH CB2016T101K | CB 2016 | 4.5 Ω | 70mA | 2x1.6x1.6 |
| 100µH CB2518T101K | CB 2518 | 2.1 Ω | 60mA | 2.5x1.8x1.8 |
| 100µH CBC2518T101K | CBC 2518 | 3.7 Ω | 160mA | 2.5x1.8x1.8 |
| 100µH CBC3225T101KR | CBC 3225 | 1.4 Ω | 270mA | 3.2x2.5x2.5 |

**Table 4.** Taiyo-Yuden Example Inductors

| Inductor Value P/N | Inductor Series | $R_{dc}$ | Saturation Current | (LxWxH) (mm) |
|---|---|---|---|---|
| 10µH LQH32CN100K33 | LQH 32C_33 | 0.3 Ω | 450mA | 3.2x2.5x2.0 |
| 10µH LQH32CN100K53 | LQH 32C_53 | 0.3 Ω | 450mA | 3.2x2.5x1.55 |
| 10µH LQH43CN100K03 | LQH 43C | 0.24 Ω | 650mA | 4.5x3.6x2.6 |
| 100µH LQH32CN101K23 | LQH 32C_23 | 3.5 Ω | 100mA | 3.2x2.5x2.0 |
| 100µH LQH32CN101K53 | LQH 32C_53 | 3.5 Ω | 100mA | 3.2x2.5x1.55 |
| 100µH LQH43CN101K03 | LQH 43C | 2.2 Ω | 190mA | 4.5x3.6x2.8 |

**Table 5.** Murata Example Inductors

### Input and STORE Capacitor Selection

Ceramic capacitors are recommended for $C_{IN}$ and $C_{STORE}$, due to ceramics' extremely low leakage currents (generally limited by very high insulation resistance). Larger value ceramics (10µF or greater) may use high constant dielectric materials, such as X5R and X7R. These materials exhibit a strong voltage coefficient and exhibit substantially lower capacitance than rated when operated near the maximum specified voltage. For these types of capacitors, use a 10V or greater voltage rating.

The STORE voltage output ripple can be reduced by increasing the value of $C_{STORE}$. Figure 5 displays the STORE output voltage ripple for two different storage capacitor values. The output voltage ripple reaches a floor value when the internal voltage comparator hysteresis becomes the dominant source of ripple. Below this level, larger capacitance does not help reduce the ripple.

**STORE Output Voltage Ripple**
**L=10µH, $C_{IN}$=10µF**
**$V_{IN}$=1.2V, STORE=3V, $I_{STORE}$=0.3µA**

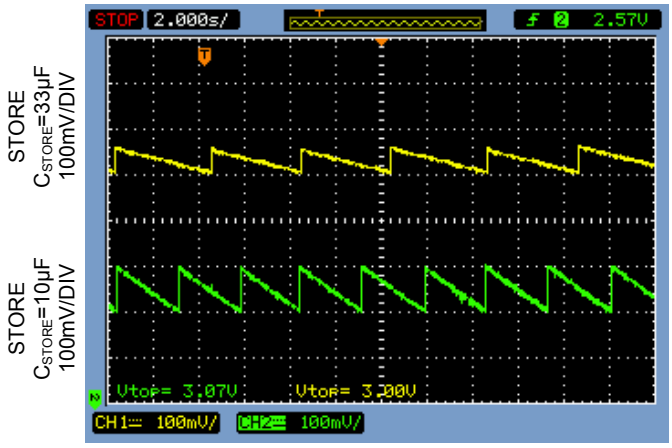



**Figure 5.** Output Voltage Ripple Comparison

### Bursted Load with Big STORE Buffer Capacitor

The TS3310 provides a switched OUT output that is capable of sourcing short bursts of large output current by utilizing a large storage capacitor at the STORE output. Figure 6 displays an application circuit that utilizes this functionality.

The circuit is powered from a LR44 1.5V Coin Cell Battery. In this example, the load needs to be powered on once every 20 seconds for 200µsec periods. The load requires a 3.3V source and demands 100mA current when it is powered on. Also in this example, the load continues to consume 10µA of leakage current when off. By attaching the load to OUT when the load isn't used, the TS3310 isolates the 10µA current so that overall quiescent current can be maintained. A 220µF storage capacitor is used for $C_{STORE}$ so that it can store the necessary charge to supply the 100mA load current. The microcontroller brings the Instant-On Load Switch, OUT_ON, high when the load needs to be powered on. The TS3310 on average consumes 160nA between load bursts.

To prevent the circuit from overloading the LR44 Coin Cell Battery, a 100µH inductor is used to ensure the TS3310 only draws 10mA of current on average while recharging $C_{STORE}$ after the load is powered off. After the load has been powered off, the TS3310 recharges the 220µF $C_{STORE}$ capacitor within 6msec and is ready for the next bursted cycle. Figure 7 displays the load being powered on for a 200µsec period and the recharge of the 220µF $C_{STORE}$ within 6msec.

**Bursted-Load with Big Store Buffer Capacitor**
**L=100µH,$C_{OUT}$=0.1µF $C_{IN}$=1µF, $C_{STORE}$=220µF**
**$V_{IN}$=1.2V, STORE=3.3V, $I_{OUT}$=100mA**

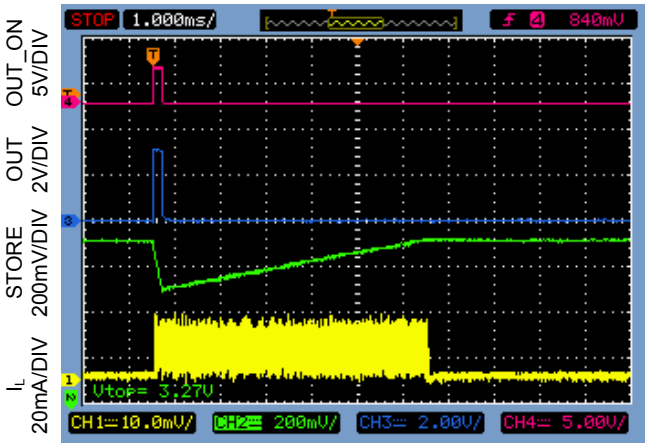



**Figure 7.** 220µF $C_{STORE}$ Recovery Scope Capture

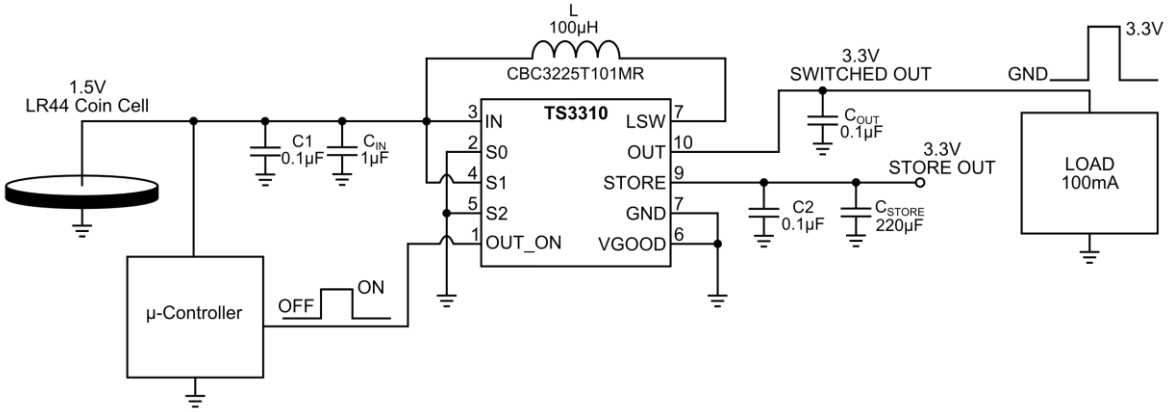
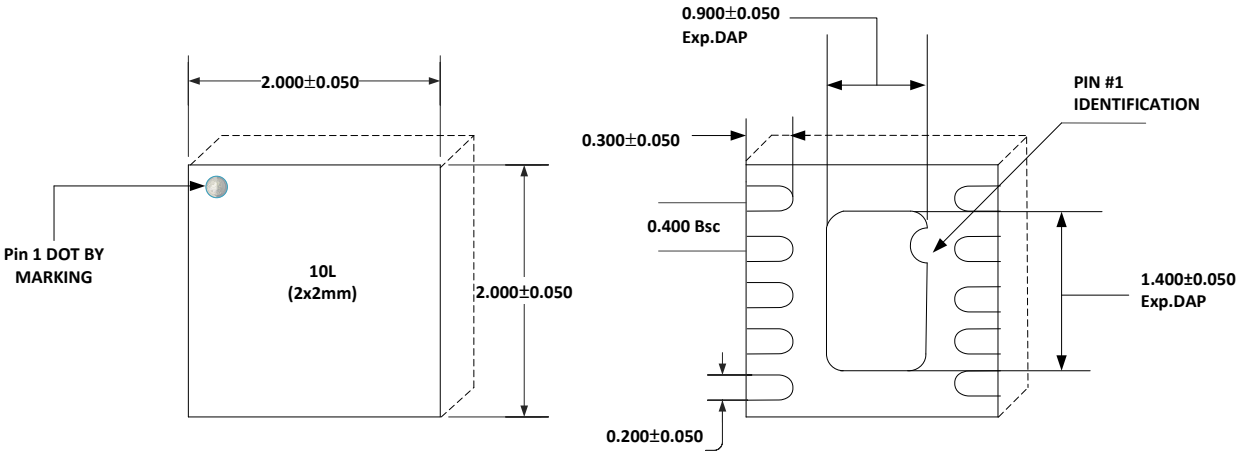
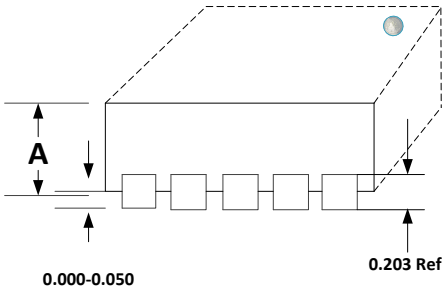



**Figure 6.** Bursted Load Application Circuit

# PACKAGE OUTLINE DRAWING




**TOP VIEW** **BOTTOM VIEW**




**SIDE VIEW**

**NOTE!**

- **All dimensions in mm.**
- **This part is compliant with JEDEC MO-229 spec**

| | | |
|---|---|---|
| **A** | MAX. | 0.800 |
| | NOM. | 0.750 |
| | MIN. | 0.700 |

**Patent Notice**

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