

NCV97310 Evaluation Board User's Manual



ON Semiconductor®

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EVAL BOARD USER'S MANUAL

Description

The NCV97310 is 3-output regulator consisting of a low-I_q battery-connected 3 A 2 MHz non-synchronous switcher and two low-voltage 1.5 A 2 MHz synchronous switchers; all using integrated power transistors.

The high-voltage switcher is capable of converting a 4.1 V to 18 V battery input to a 5 V or 3.3 V output at a constant 2 MHz switching frequency, delivering up to 3 A. In overvoltage conditions up to 36 V, the switching frequency folds back to 1 MHz; in load dump conditions up to 45 V the regulator shuts down.

The output of the battery-connected buck regulator serves as the low voltage input for the 2 synchronous switchers. Each downstream output is adjustable from 1.2 V to 3.3 V, with a 1.5 A current limit and a constant 2 MHz switching frequency. Each switcher has independent enable and reset pins, giving extra power management flexibility.

For low-I_q operating mode the low-voltage switchers are disabled, and the standby rail is supplied by a low-I_q LDO (up to 150 mA) with a typical I_q of 30 μ A. The LDO regulator is in parallel to the high-voltage switcher, and is activated when the switcher is forced in standby mode.

All 3 SMPS outputs use peak current mode control with internal slope compensation, internally-set soft-start, battery undervoltage lockout, battery overvoltage protection, cycle-by-cycle current limiting, hiccup mode short-circuit protection and thermal shutdown. An error flag is available for diagnostics.

Key Features

- Low Quiescent Current in Standby Mode
- 2 Microcontroller Enabled Low Voltage Synchronous Buck Converters
- Large Conversion Ratio of 18 V to 3.3 V Battery Connected Switcher
- Wide Input of 4.1 to 45 V with Undervoltage Lockout (UVLO)
- Fixed Frequency Operation Adjustable from 2.0 to 2.6 MHz
- Internal 1.5 ms Soft-starts
- Cycle-by-Cycle Current Limit Protections
- Hiccup Overcurrent Protections (OCP)
- Individual Reset Pins with Adjustable Delays
- These Devices are Pb-Free, Halogen Free/BFR Free and are RoHS Compliant

Typical Applications

- Infotainment, Body Electronics, Telematics, ECU

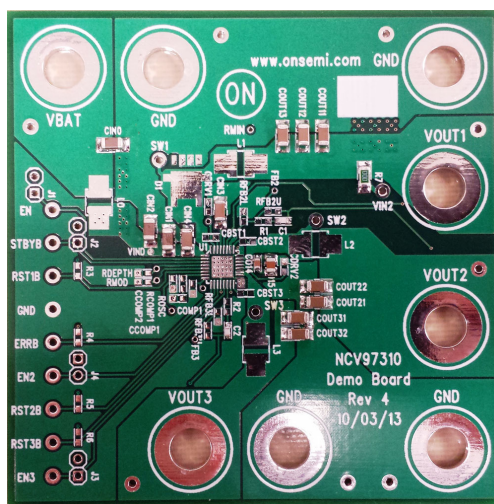


Figure 1. Evaluation Board Photo

NCV97310MW33GEVB

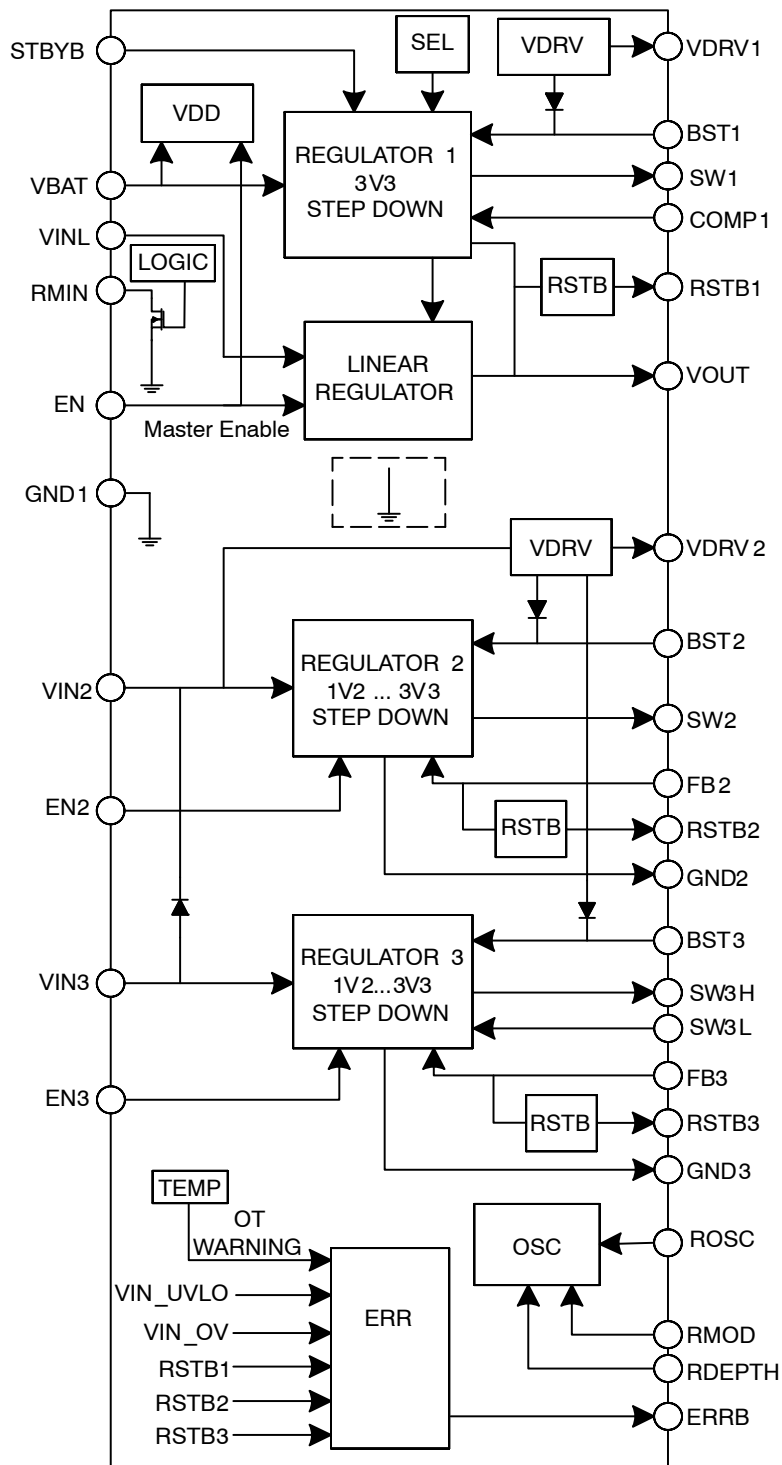


Figure 2. NCV97310 Block Diagram

NCV97310MW33GEVB

TYPICAL APPLICATION

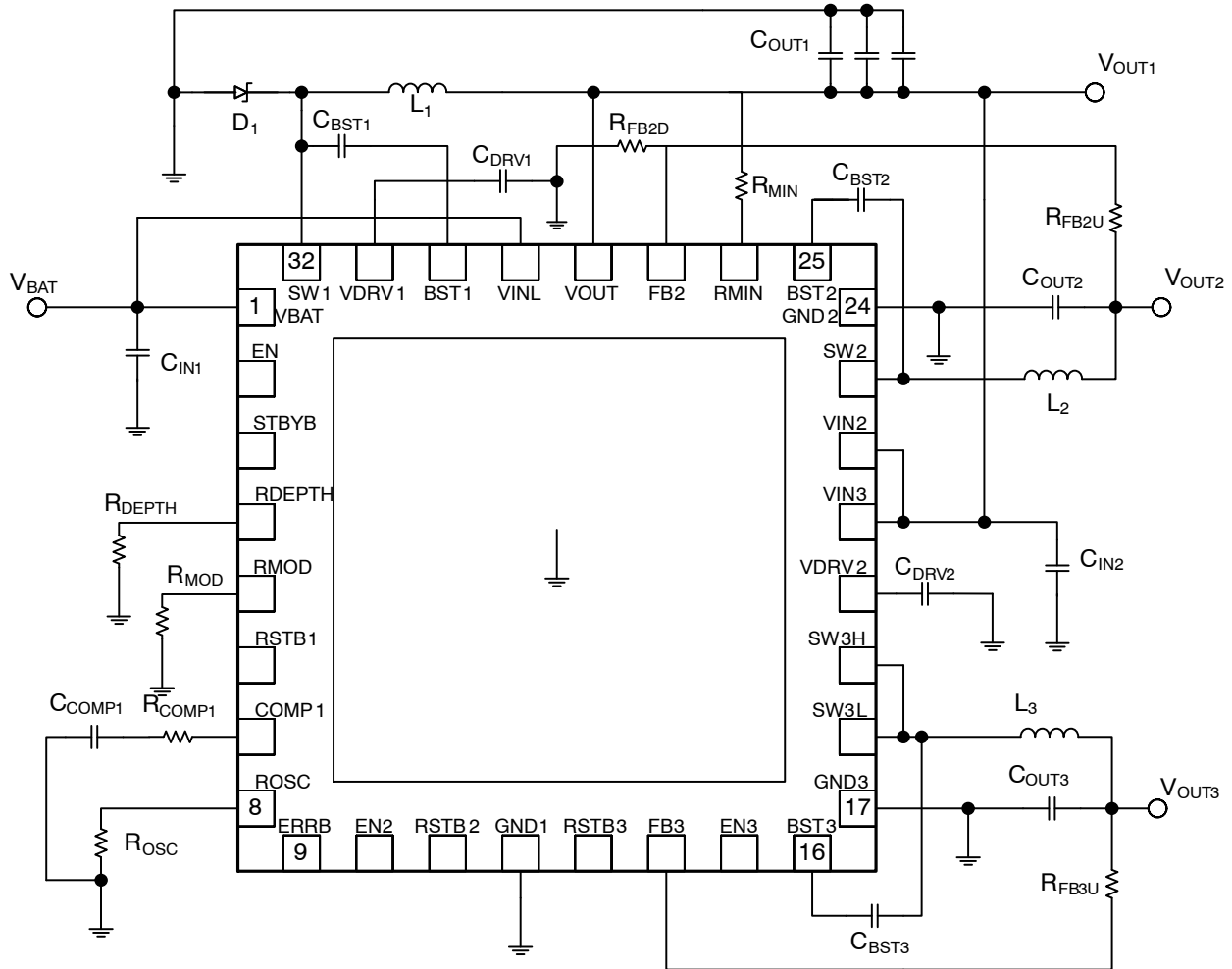


Figure 3. Typical Application

Table 1. EVALUATION BOARD TERMINALS

| Pin Name | Function |
|----------|--|
| VBAT | Positive dc input voltage |
| GND | Common dc return |
| VOUT1 | Positive 3.3 V dc output voltage (LDO/Switcher 1) |
| VOUT2 | Positive DC output voltage (Switcher 2) |
| VOUT3 | Positive DC output voltage (Switcher 3) |
| EN | Master enable input. Includes jumper J3 to connect to VBAT. |
| STBYB | Standby enable input. Includes jumper J4 to connect to VBAT. |
| EN2 | Switcher 2 enable input. Includes jumper J6 to connect to VOUT1. |
| EN3 | Switcher 3 enable input. Includes jumper J5 to connect to VOUT1. |
| ERRB | Error flag combining temperature and input and output voltage sensing. |
| RST1B | Reset with adjustable delay. Goes low when the VOUT1 is out of regulation. |
| RST2B | Reset with adjustable delay. Goes low when the VOUT2 is out of regulation. |
| RST3B | Reset with adjustable delay. Goes low when the VOUT3 is out of regulation. |

NCV97310MW33GEVB

Table 2. ABSOLUTE MAXIMUM RATINGS (Voltages are with respect to GND)

| Rating | Value | Unit |
|--|------------|------|
| Dc Supply Voltage (VBAT, EN, STBYB) | -0.3 to 36 | V |
| Dc Supply Voltage (VIN2, VIN3) | -0.3 to 12 | V |
| Dc Supply Voltage (RSTB1, RSTB2, RSTB3, ERB, EN2, EN3) | -0.3 to 6 | V |
| Storage Temperature Range | -55 to 150 | °C |

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

Table 3. ELECTRICAL CHARACTERISTICS (TA = 25°C, 4.5 ≤ VIN ≤ 18 V, IOUT ≤ 2 A, unless otherwise specified)

| Characteristic | Conditions | Typical Value | Unit |
|----------------|------------|---------------|------|
|----------------|------------|---------------|------|

REGULATION

| | | | |
|-------------------------|---------------|-------|---|
| Output Voltage (VOUT1) | | 3.3 | V |
| Output Voltage (VOUT2) | | 1.8 | V |
| Output Voltage (VOUT3) | | 1.2 | V |
| Line Regulation (VOUT1) | IOUT1 = 1.0 A | 0.03 | % |
| Line Regulation (VOUT2) | IOUT2 = 1.0 A | 0.01 | % |
| Line Regulation (VOUT3) | IOUT3 = 1.0 A | 0.001 | % |
| Load Regulation (VOUT1) | VBAT = 13.2 V | 0.3 | % |
| Load Regulation (VOUT2) | VBAT = 13.2 V | 0.02 | % |
| Load Regulation (VOUT3) | VBAT = 13.2 V | 0.03 | % |

SWITCHING

| | | | |
|----------------------|----------------------|------------|-----|
| Switching Frequency | | 2.0 | MHz |
| Soft-start Time | | 1.4 | ms |
| ROSC Frequency Range | 50 kΩ ≥ ROSC ≥ 10 kΩ | 2.0 to 2.6 | MHz |

CURRENT LIMIT

| | | | |
|----------------------------|-------------|-----|---|
| Peak Current Limit (VOUT1) | STBYB = 0 V | 0.2 | A |
| Peak Current Limit (VOUT1) | STBYB = 5 V | 4.4 | A |
| Peak Current Limit (VOUT2) | | 2.9 | A |
| Peak Current Limit (VOUT3) | | 2.9 | A |

PROTECTION

| | | | |
|-----------------------------------|-----------------|-----|----|
| Input Undervoltage Lockout (UVLO) | VBAT Decreasing | 3.9 | V |
| Input Overvoltage Protection | VBAT Increasing | 36 | V |
| Thermal Warning | TJ Rising | 150 | °C |
| Thermal Shutdown | TJ Rising | 170 | °C |

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

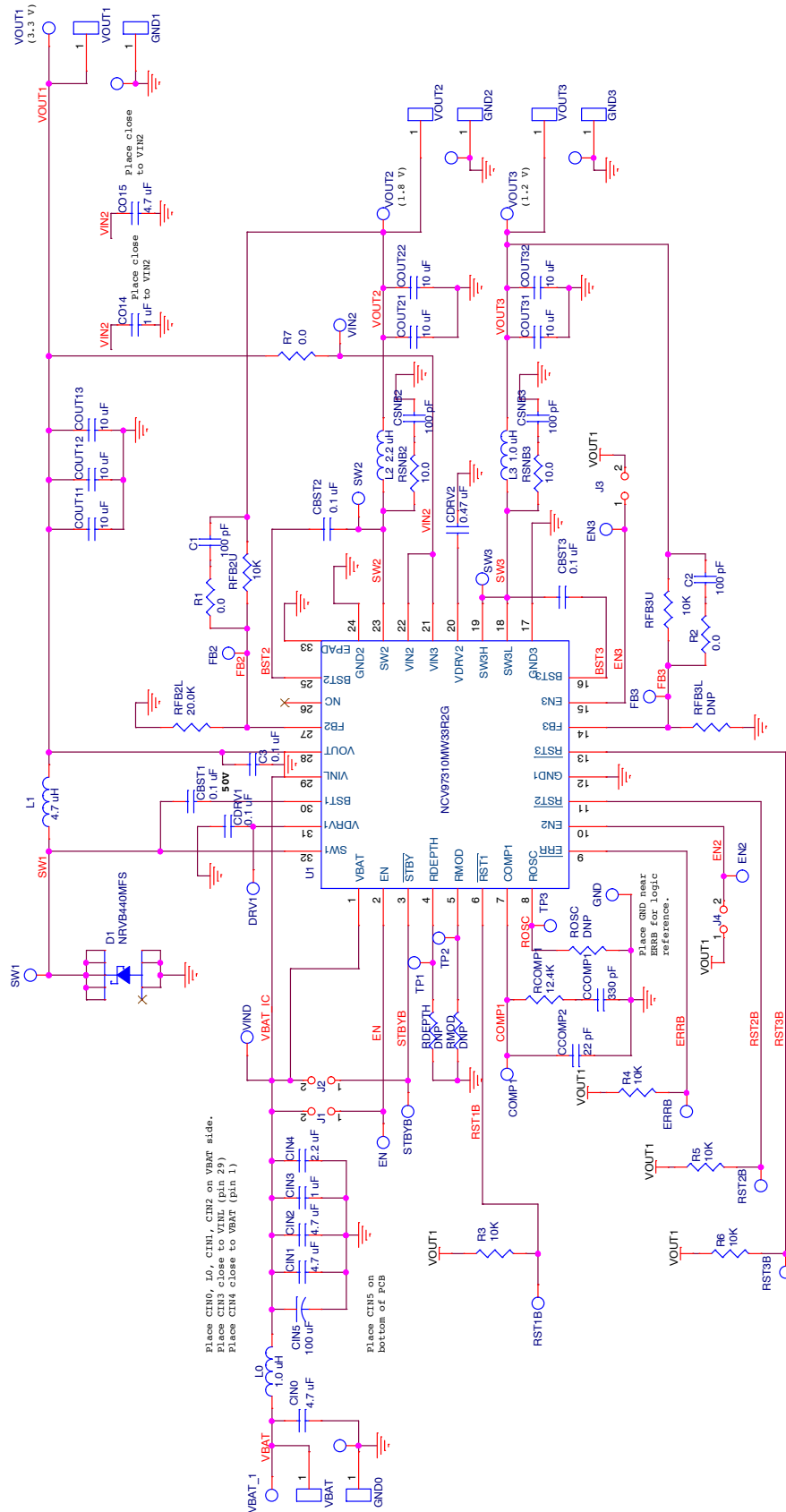


Figure 4. NCV97310GEVB 3.3 V Board Schematic

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Operational Guidelines

1. Connect a dc input voltage, within the 6.0 V to 36 V range, between VBAT and GND.
2. Connect a load (< 150 mA) between VOUT1 and GND
3. Connect a dc enable voltage, within the 2.0 V to 36 V range, between EN and GND. This will enable the internal LDO for low Iq mode. You may use jumper J1 to connect EN directly to VBAT.
 - a. The VOUT1 signal should be 3.3 V.
 - b. The VOUT2 signal should be disabled (regardless of EN2 state) and read 0 V.
 - c. The VOUT3 signal should be disabled (regardless of EN3 state) and read 0 V.
4. Connect a dc enable voltage, within the 2.0 V to 36 V range, between STBYB and GND. This will exit low Iq mode and power up switcher 1. You may use jumper J2 to connect STBYB directly to VBAT.

The VOUT1 signal should still be 3.3 V. You may now add a higher load to VOUT1.
5. Connect a dc enable voltage, within the 2.0 V to 6 V range, between EN2 and GND. This will power up switcher 2. You may use jumper J4 to connect EN2 directly to VOUT1.

The VOUT2 signal should be 1.8 V.
6. Connect a dc enable voltage, within the 2.0 V to 6 V range, between EN3 and GND. This will power up switcher 3. You may use jumper J3 to connect EN3 directly to VOUT1.

The VOUT3 signal should be 1.2 V.

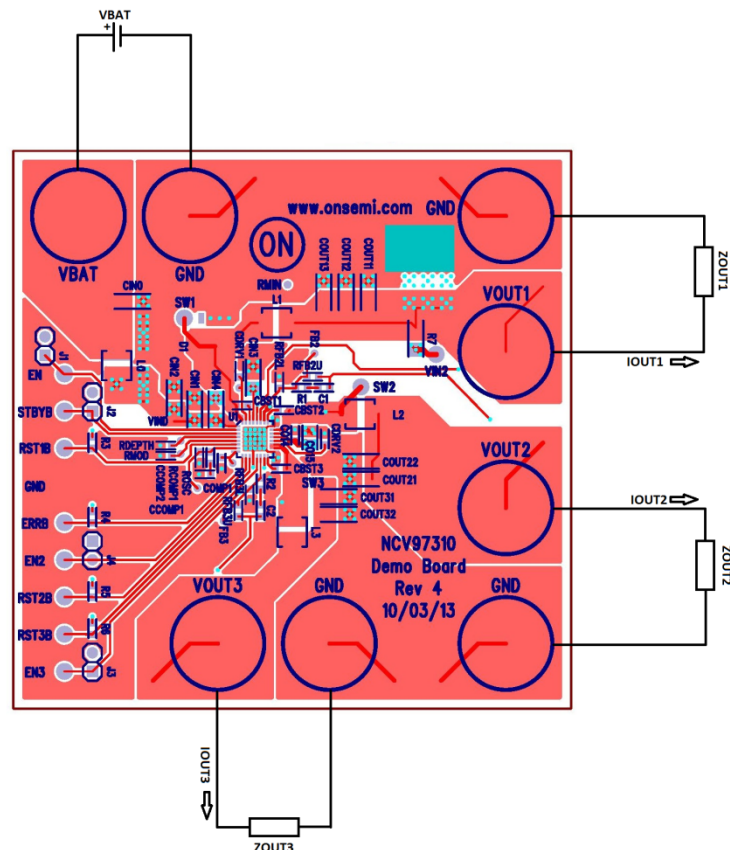
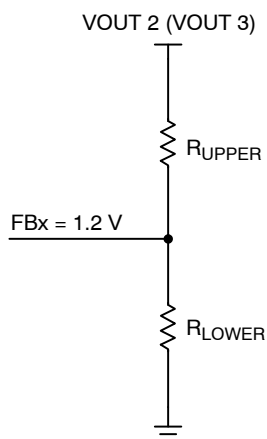


Figure 5. NCV97310 Board Connections

APPLICATION INFORMATION

Output Voltage Selection

The voltage outputs for switcher 2 and switcher 3 are adjustable and can be set with a resistor divider. The FB reference for both switchers is 1.2 V.



The upper resistor is set to 10 kΩ and is part of the feedback loop. To maintain stability over all conditions, it is recommended to change the only the lower feedback resistor to set the output voltage. Use the following equation:

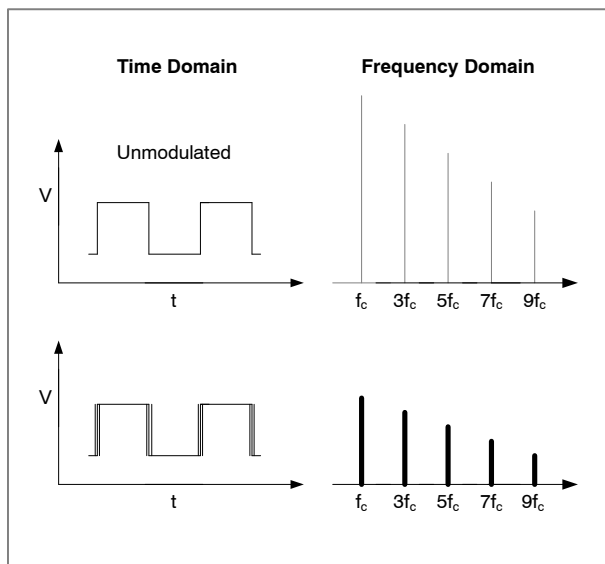
$$R_{\text{LOWER}} = R_{\text{UPPER}} \frac{V_{\text{FB}}}{V_{\text{OUT}} - V_{\text{FB}}}$$

Some common setups are listed below:

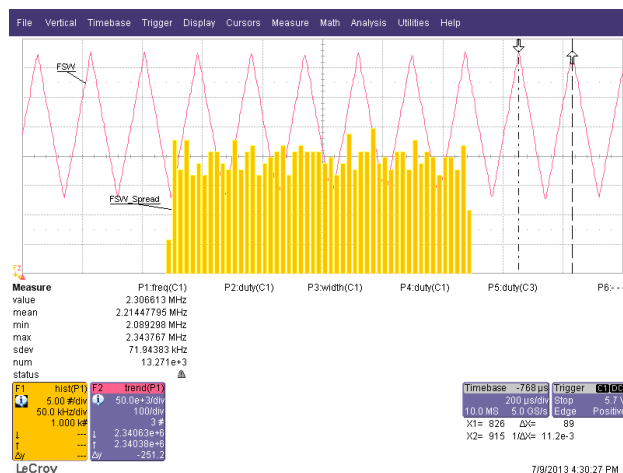
| Desired Output (V) | VREF (V) | R _{UPPER} (kΩ, 1%) | R _{LOWER} (kΩ, 1%) |
|--------------------|----------|-----------------------------|-----------------------------|
| 1.2 | 1.2 | 10.0 | NP |
| 1.5 | 1.2 | 10.0 | 40.0 |
| 1.8 | 1.2 | 10.0 | 20.0 |
| 2.5 | 1.2 | 10.0 | 9.31 |
| 3.3 | 1.2 | 10.0 | 5.76 |

Spread Spectrum

In SMPS devices, switching translates to higher efficiency. Unfortunately, the switching leads to a much noisier EMI profile. We can greatly decrease some of the radiated emissions with some spread spectrum techniques. Spread spectrum is used to reduce the peak electromagnetic emissions of a switching regulator.

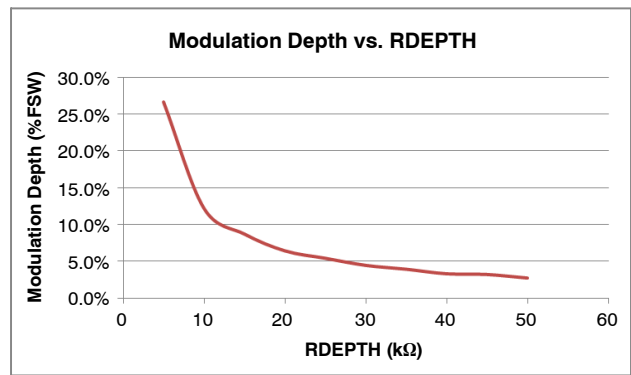
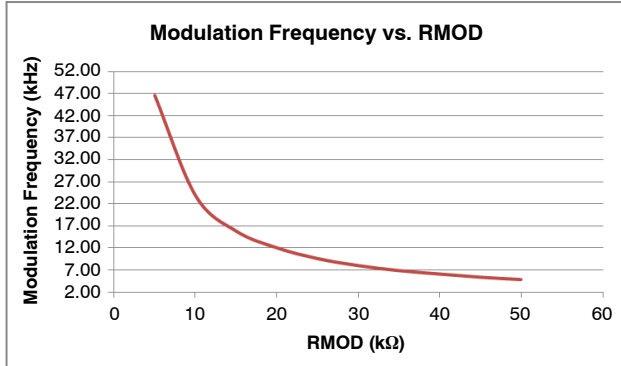


The spread spectrum used in the NCV97310 is an “up-spread” technique, meaning the switching frequency is spread upward from the 2.0 MHz base frequency. For example, a 5 % spread means that the switching frequency is swept (spread) from 2.0 MHz up to 2.1 MHz in a linear fashion – this is called the modulation depth. The rate at which this spread takes place is called the modulation frequency. For example, a 10 kHz modulation frequency means that the frequency is swept from 2.0 MHz to 2.1 MHz in 50 μs and then back down from 2.1 MHz to 2.0 MHz in 50 μs.



NCV97310MW33GEVB

The modulation depth and modulation frequency are each set by 2 external resistors to GND. The modulation frequency can be set from 5 kHz up to 50 kHz using a resistor from the RMOD pin to GND. The modulation depth can be set from 3% up to 30% of the nominal switching frequency using a resistor from the RDEPTH pin to GND. Please see the curves below for typical values:



Spread spectrum is automatically turned off when there is a short to GND or an open circuit on either the RMOD pin or the RDEPTH pin. Please be sure that the ROSC pin is an open circuit when using spread spectrum.

TYPICAL PERFORMANCE

Efficiency

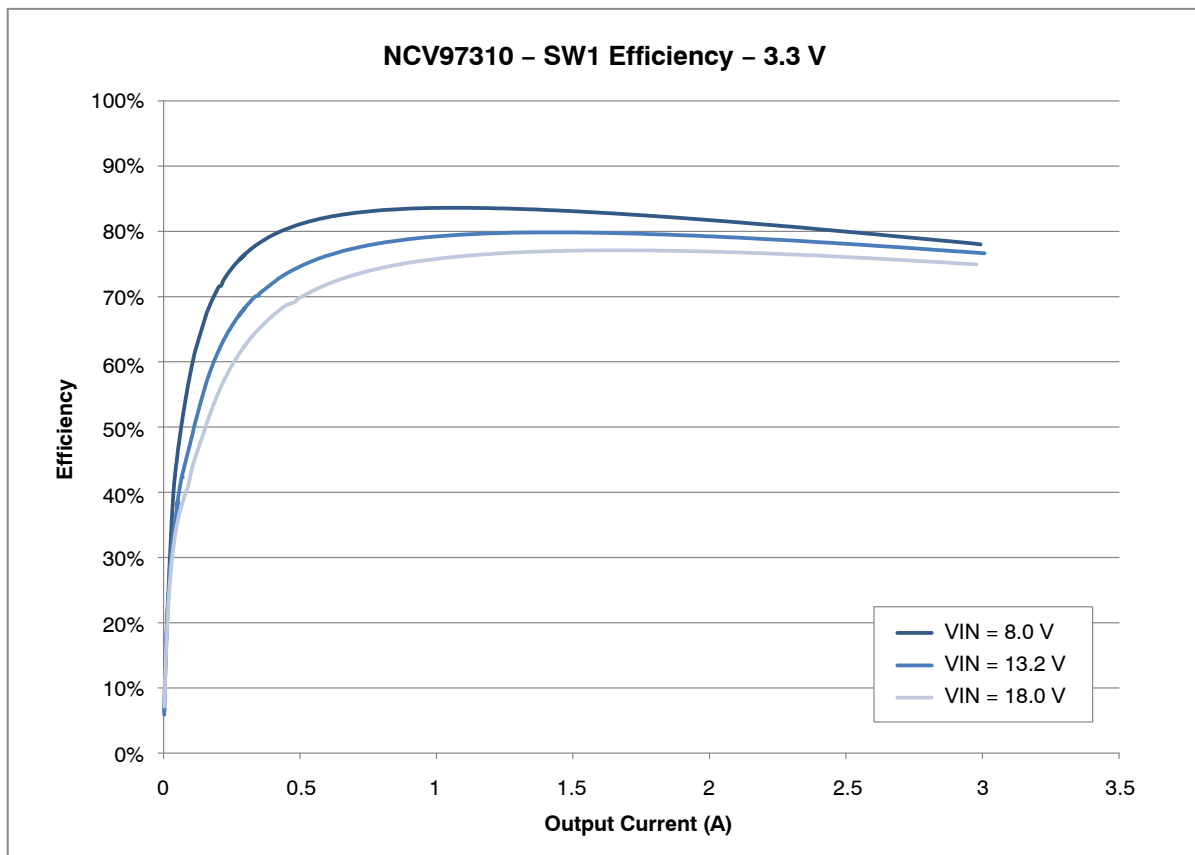


Figure 6. Efficiency for SW1 with a 3.3 V Output

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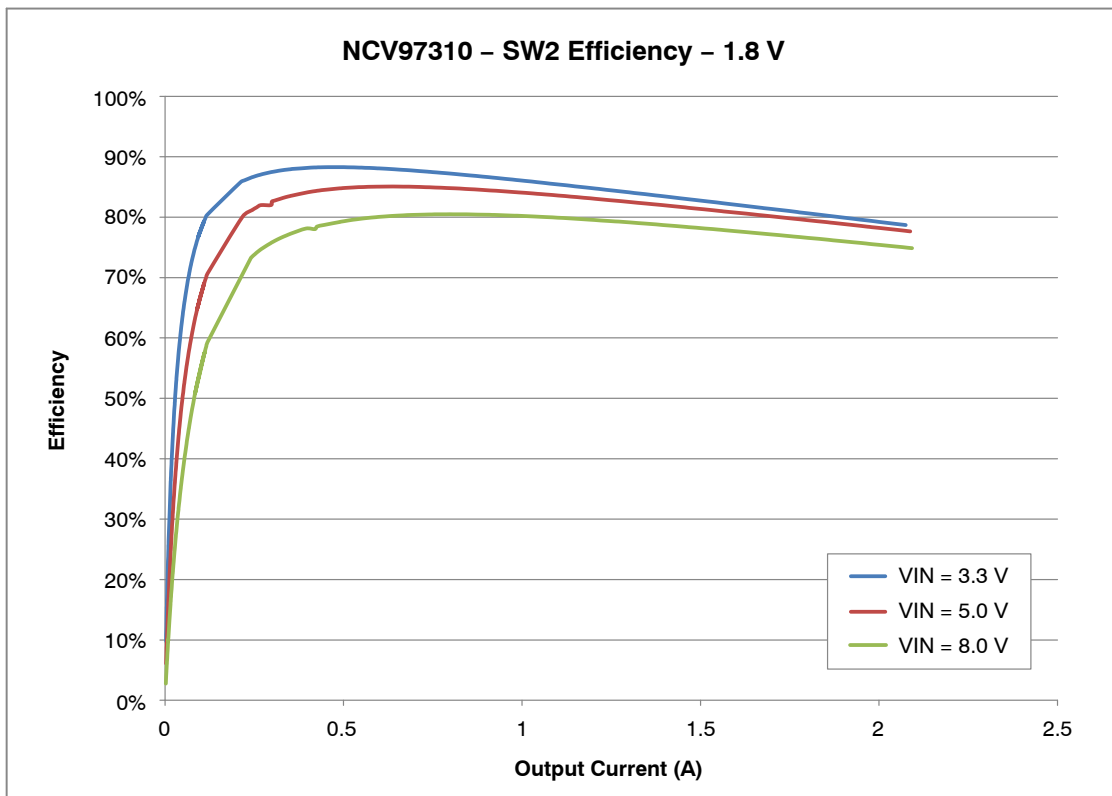


Figure 7. Efficiency for SW2 with a 1.8 V Output

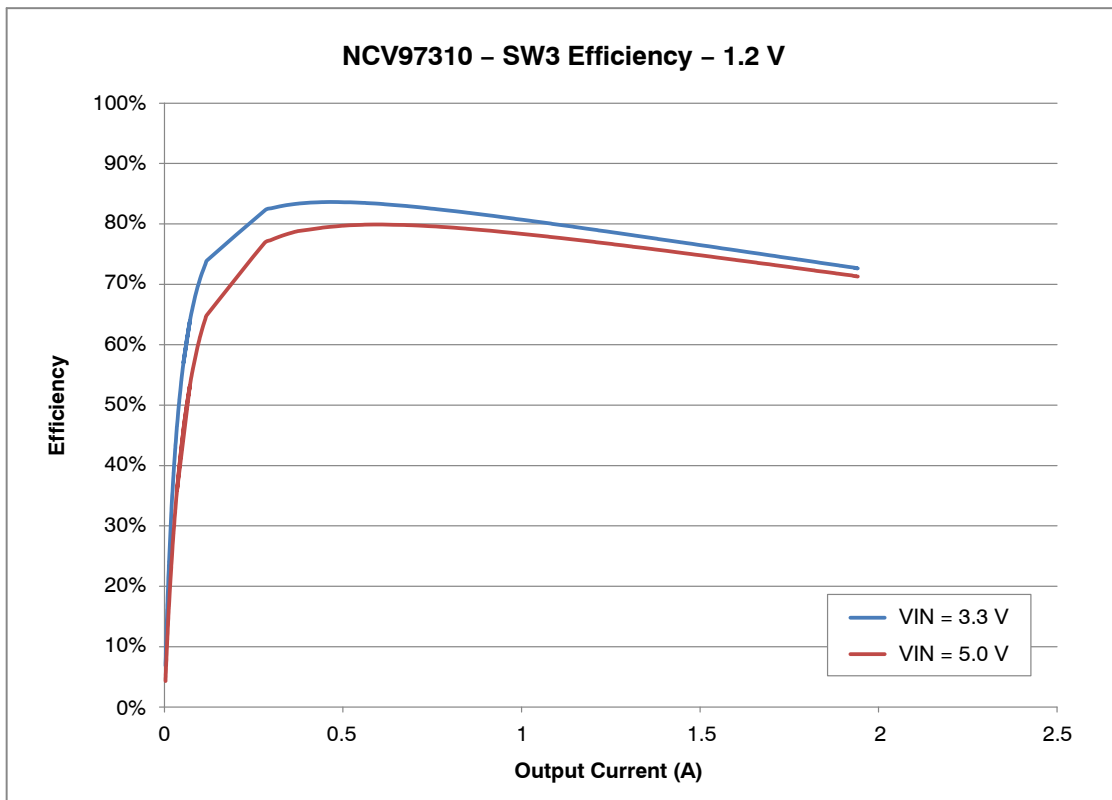


Figure 8. Efficiency for SW3 with a 1.2 V Output

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Line Regulation

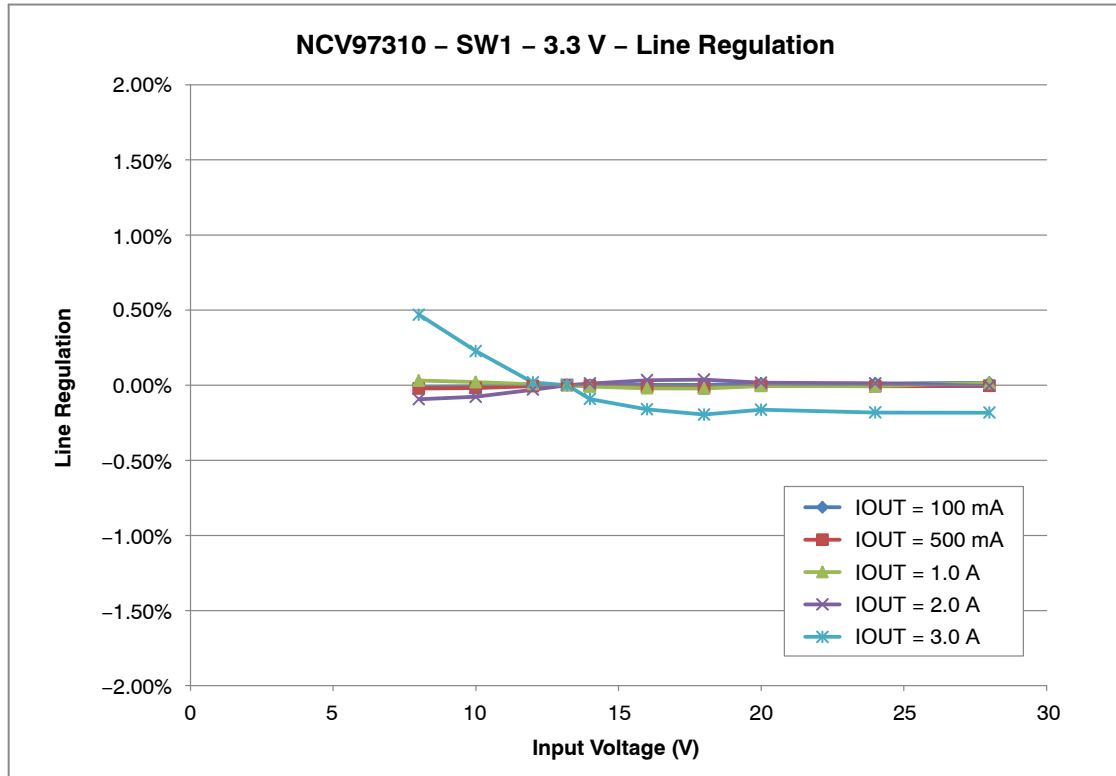


Figure 9. Line Regulation for SW1 with a 3.3 V Output

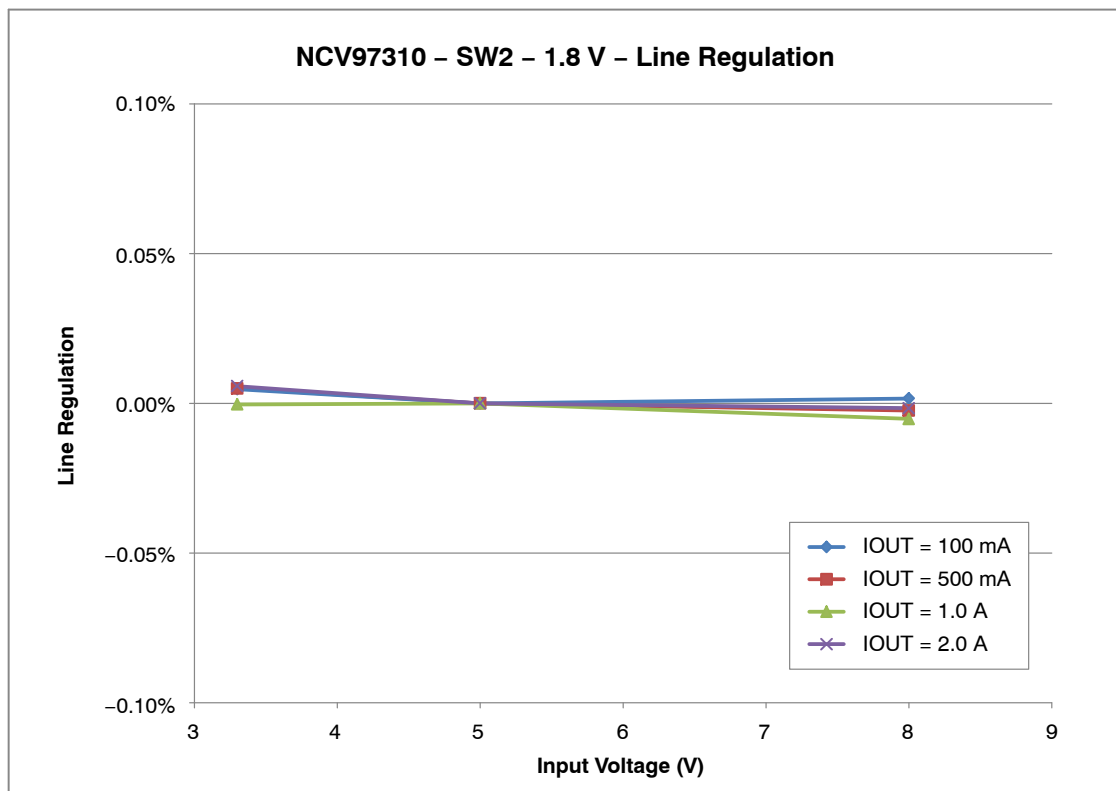


Figure 10. Line Regulation for SW2 with a 1.8 V Output

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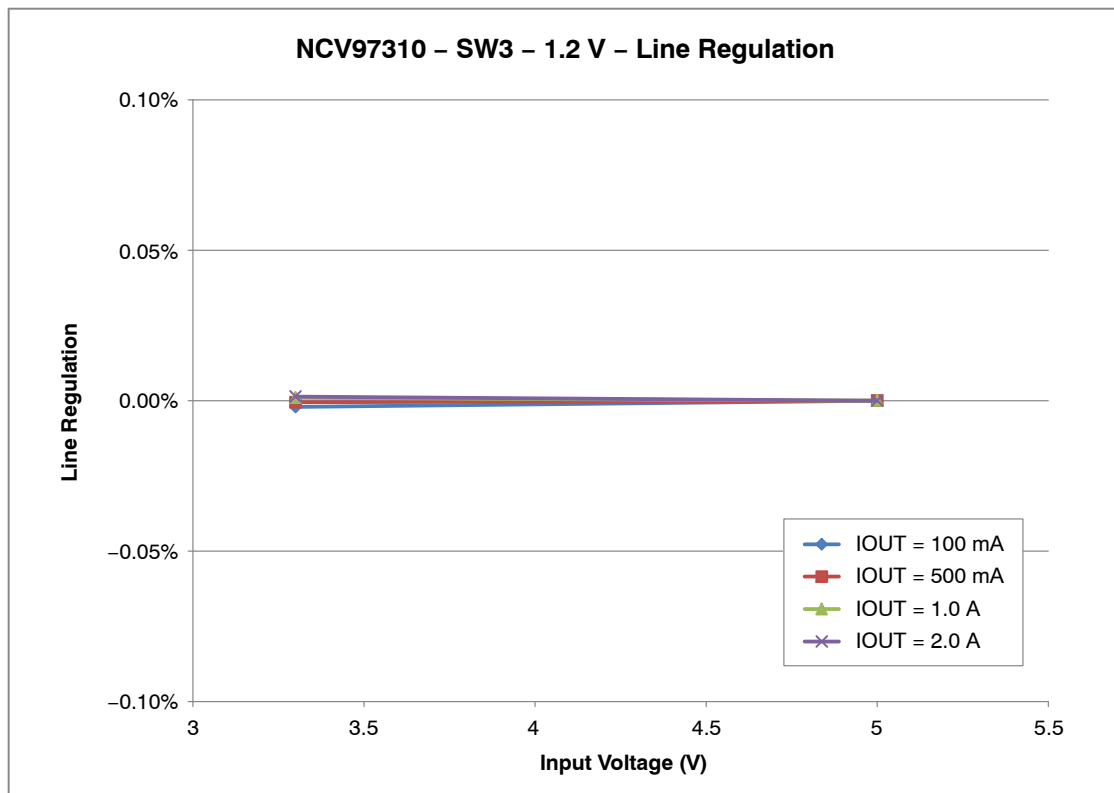


Figure 11. Line Regulation for SW3 with a 1.2 V Output

Load Regulation

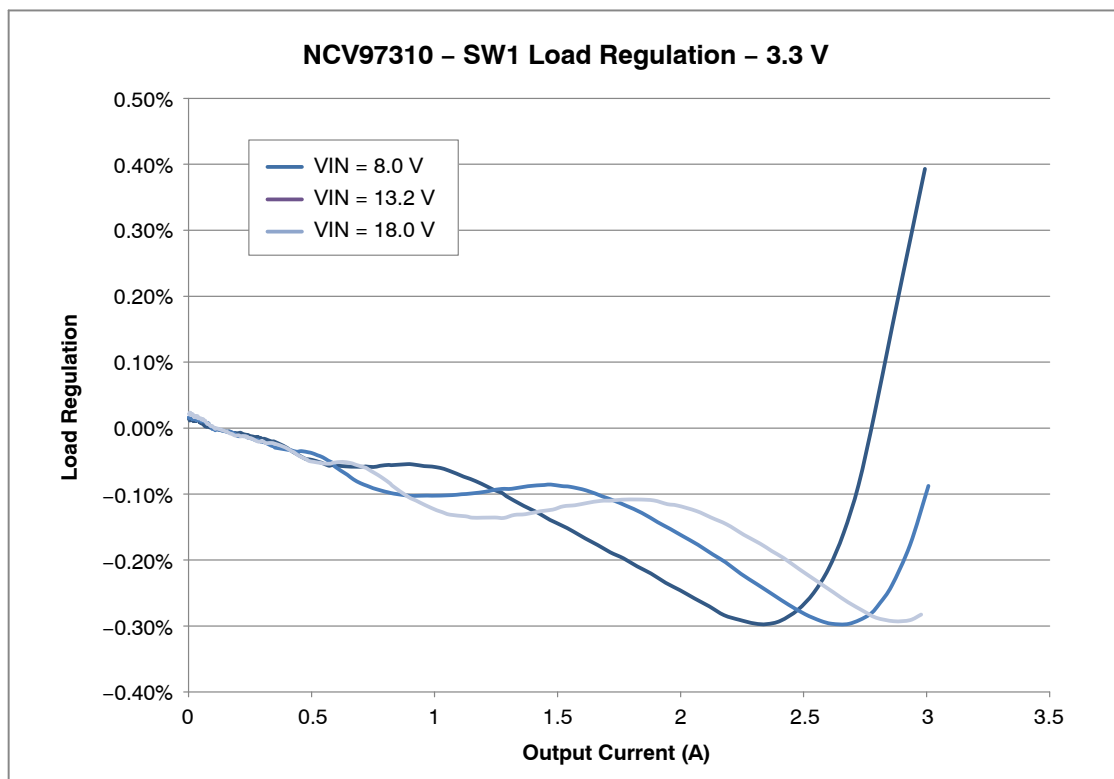


Figure 12. Load Regulation for SW1 with a 3.3 V Output

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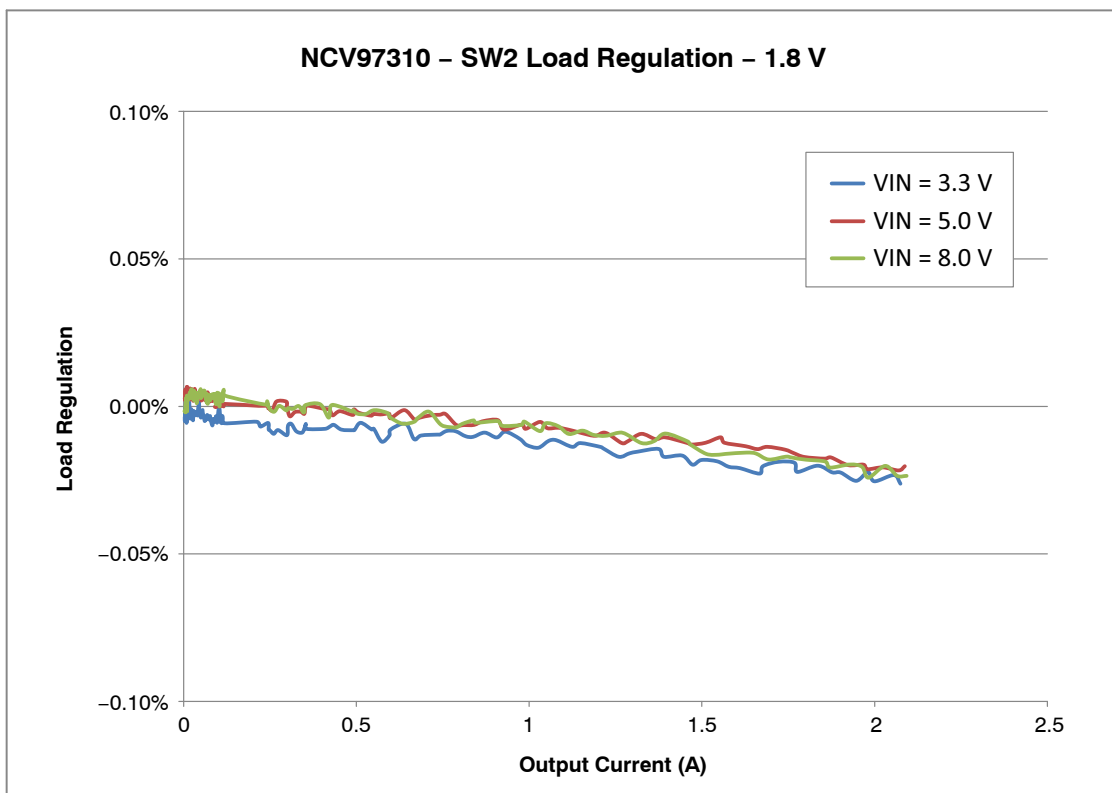


Figure 13. Load Regulation for SW2 with a 1.8 V Output

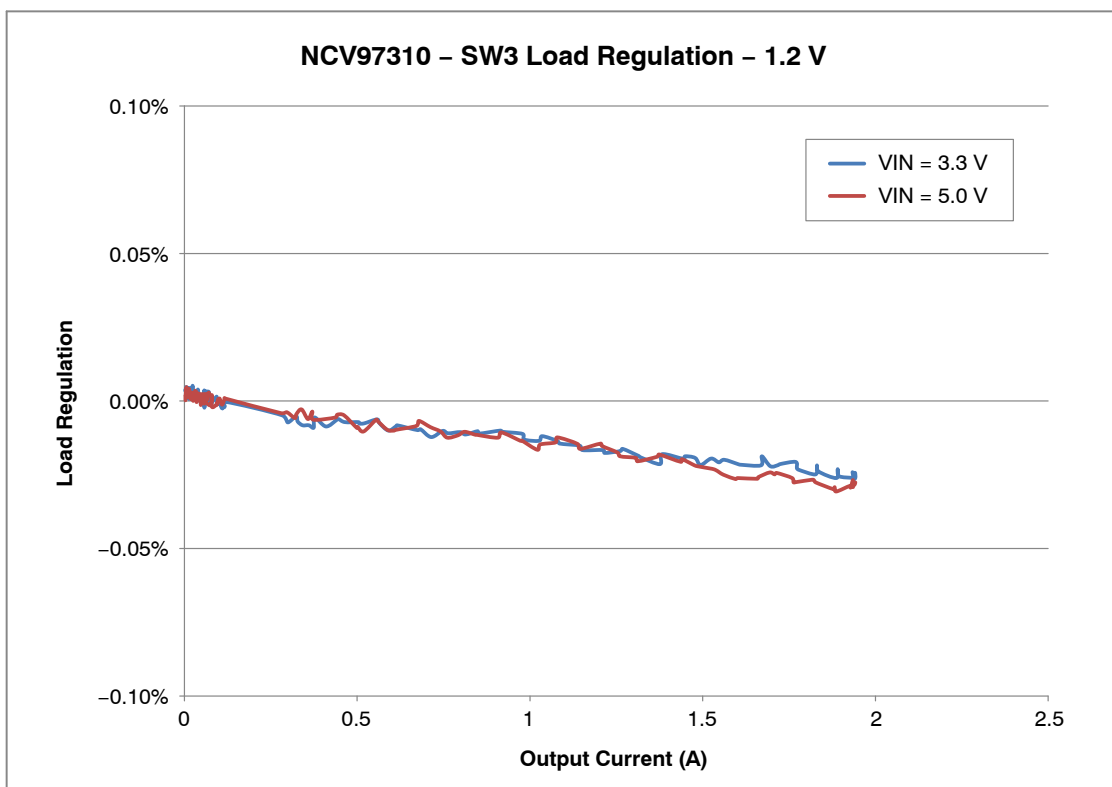
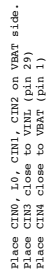


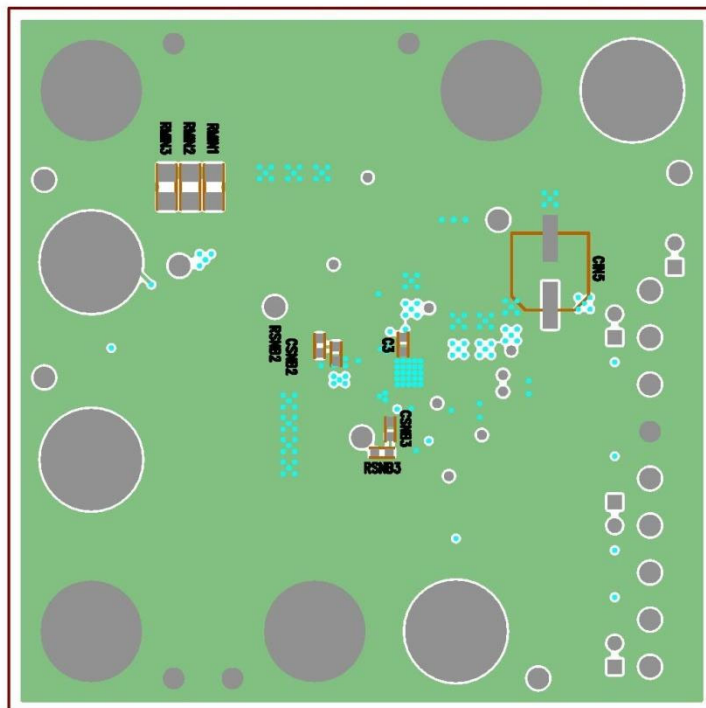
Figure 14. Load Regulation for SW3 with a 1.2 V Output

SCHEMATIC



PCB LAYOUT

NCV97310 Evaluation Board Rev 4 10/03/13 – BOTTOM Layer (mirrored)



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NCV97310MW33GEVB

BILL OF MATERIALS

Table 4. BILL OF MATERIALS

| Reference Designator(s) | Qty. | Description | Value | Tolerance | Footprint | Manufacturer | Manufacturer's Part Number | Substitution Allowed |
|--|------|--|-----------------|-----------|-----------|----------------------------------|----------------------------|----------------------|
| C1, C2, CSNB2, CSNB3 | 4 | CAP CER 100 pF 50 V 5% NP0 0603 | 100 pF | 5% | 603 | Murata Electronics North America | GCM1885C1H101JA16D | Yes |
| C3, CBST1, CBST2, CBST3, CDRV1 | 5 | CAP CER 0.1 μ F 50 V 10% X7R 0603 | 0.1 μ F | 10% | 603 | Murata Electronics North America | GCM188R71H104KA57D | Yes |
| CCOMP1 | 1 | CAP CER 330 pF 50 V 5% NP0 0603 | 330 pF | 5% | 603 | Murata Electronics North America | GCM1885C1H331JA16D | Yes |
| CCOMP2 | 1 | CAP CER 22 pF 50 V 5% NP0 0603 | 22 pF | 5% | 603 | Murata Electronics North America | GCM1885C1H220JA16D | Yes |
| CDRV2 | 1 | CAP CER 0.47 μ F 16 V 10% X7R 0603 | 0.47 μ F | 10% | 603 | Murata Electronics North America | GCM188R71C474KA55D | Yes |
| CIN0, CIN1, CIN2 | 3 | CAP CER 4.7 μ F 50 V 10% X7R 1206 | 4.7 μ F | 10% | 1206 | TDK Corporation | C3216X7R1H475K160AC | Yes |
| CIN3 | 1 | CAP CER 1.0 μ F 50 V 10% X7R 1206 | 1.0 μ F | 10% | 1206 | Murata Electronics North America | GCM31MR71H105KA55L | Yes |
| CIN4 | 1 | CAP CER 2.2 μ F 50 V 10% X7R 1206 | 2.2 μ F | 10% | 1206 | Murata Electronics North America | GCM31CR71H225KA55L | Yes |
| CIN5 | 1 | CAP ALUM 100 μ F 50 V 20% SMD | 100 μ F | 20% | FK_V_E | Chemi-Con | EMZA500ADA101MHA0G | Yes |
| CO14 | 1 | CAP CER 1 μ F 16 V 10% X7R 0603 | 1.0 μ F | 10% | 603 | Murata Electronics North America | GCM188R71C105KA64D | Yes |
| CO15 | 1 | CAP CER 4.7 μ F 16 V 10% X7R 0805 | 4.7 μ F | 10% | 805 | TDK Corporation | CGA4J3X7R1C475K125AB | Yes |
| COUT11, COUT12, COUT13, COUT21, COUT22, COUT31, COUT32 | 7 | CAP CER 10 μ F 10 V 10% X7R 1206 | 10 μ F | 10% | 1206 | Murata Electronics North America | GCM31CR71A106KA64L | Yes |
| R1, R2 | 2 | RES 0.0 Ω 1/10 W 0603 SMD | 0 Ω | Jumper | 603 | Vishay/Dale | CRCW06030000Z0EA | Yes |
| R3, R4, R5, R6, RFB2U, RFB3U | 6 | RES 10.0 k Ω 1/10 W 1% 0603 SMD | 10.0 k Ω | 1% | 603 | Vishay/Dale | CRCW060310K0FKEA | Yes |
| R7 | 1 | RES 0.0 Ω 1/4 W 1206 SMD | 0 Ω | Jumper | 1206 | Vishay/Dale | CRCW12060000Z0EA | Yes |
| RCOMP1 | 1 | RES 12.4 k Ω 1/10 W 1% 0603 SMD | 12.4 k Ω | 1% | 603 | Vishay/Dale | CRCW060312K4FKEA | Yes |
| RFB2L | 1 | RES 5.76 k Ω 1/10 W 1% 0603 SMD | 5.76 k Ω | 1% | 603 | Vishay/Dale | CRCW06035K76FKEA | Yes |
| RSNB2, RSNB3 | 2 | RES 10.0 Ω 1/10 W 1% 0603 SMD | 10.0 Ω | 1% | 603 | Vishay/Dale | CRCW060310R0FKEA | Yes |
| D1 | 1 | DIODE SCHOTTKY 4.0 A 40 V SMB | 40 V/4.0 A | N/A | SMB_DIODE | ON Semiconductor | NRVB440MFST1G | No |

NCV97310MW33GEVB

Table 4. BILL OF MATERIALS (continued)

| Reference Designator(s) | Qty. | Description | Value | Tolerance | Footprint | Manufacturer | Manufacturer's Part Number | Substitution Allowed |
|--|------|---|-----------------|-----------|---------------|--|----------------------------|----------------------|
| L0, L3 | 2 | High Current Shielded Inductor 1.0 μ H, 8.7 A SAT | 1.0 μ H | 20% | XAL4020-102ME | Coilcraft | XAL4020-102ME | No |
| L1 | 1 | High Current Shielded Inductor 4.7 μ H, 4.5 A SAT | 4.7 μ H | 20% | XAL4030-472ME | Coilcraft | XAL4030-472ME | No |
| L2 | 1 | High Current Shielded Inductor 2.2 μ H, 5.6 A SAT | 2.2 μ H | 20% | XAL4020-222ME | Coilcraft | XAL4020-222ME | No |
| EN, EN2, EN3, ERRB, GNDL, PGND1_1, PGND1_2, PGND2_1, PGND3_1, RST1B, RST2B, RST3B, STBYB, SW1, SW2, SW3, VIN2, VBAT, VOUT1_1, VOUT2_1, VOUT3_1 | 21 | PIN INBOARD .042" HOLE 1000/PKG | N/A | N/A | TP | Vector Electronics | K24C/M | Yes |
| GND0, GND1, GND2, GND3, VBAT, VOUT1, VOUT2, VOUT3 | 8 | CONN JACK BANANA UNINS PANEL MOU | N/A | N/A | BANANA | Emerson Network Power Connectivity Johnson | 108-0740-001 | No |
| J1, J2, J3, J4 | 4 | CONN HEADER 2POS .100 VERT GOLD | N/A | N/A | JMP | Molex Connector Corporation | 22-28-4023 | Yes |
| | 4 | CONN JUMPER SHORTING GOLD | N/A | N/A | JMP | Sullins Connector Solutions | SSC02SYAN | Yes |
| COMP1, DRV1, FB2, FB3, RMIN, TP1, TP2, TP3, VIND | 9 | CIRCUIT PIN PRNTD .020"D .425"L | Do Not Populate | N/A | SMALLTP | Mill-Max Manufacturing Corp. | 3128-2-00-15-00-00-08-0 | Yes |
| RDEPTH, RFB3L, RMOD, ROSC | 4 | | Do Not Populate | | 603 | | | Yes |
| U1 | 1 | Automotive Battery-Connected Low IQ Multi-Output PMU | N/A | N/A | QFN32 | ON Semiconductor | NCV97310MW33R2G | No |

NOTE: All devices are RoHS Compliant.

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