NCV887601

Small-Signal PSPICE Model

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The NCV887601-SMS_revX.LIB library file is a small-signal implementation of the Start-Stop boost controller (NCV887600, NCV887601) intended for AC analysis (cannot be used for large-signal transient analysis). The model is intended for feedback loop stability analysis of an NCV887601 controller in a boost topology.

The example PSPICE file demonstrates the model implementation used for the NCV887601BSTGEVB evaluation demo board (Fig. 1).

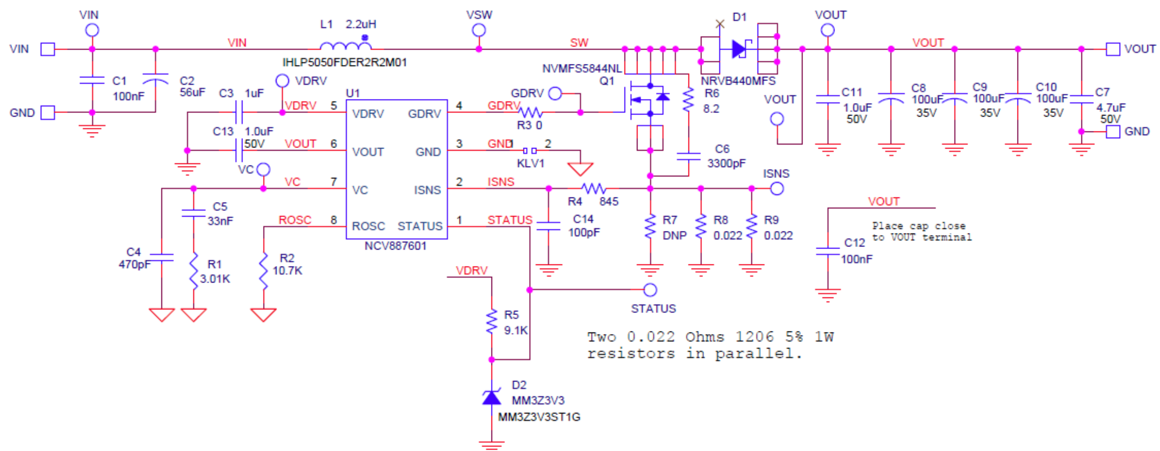

Figure 1 NCV887601BSTGEVB Evaluation Board Schematic

Modeled Elements

This NCV887601-SMS_revX.LIB model is a modification of the public domain current-mode lossy switch PWMCM_LX.LIB model created by Christophe Basso [1]. The corresponding NCV887601-SMS_revX.OLB symbol representation is shown in Figure 2.

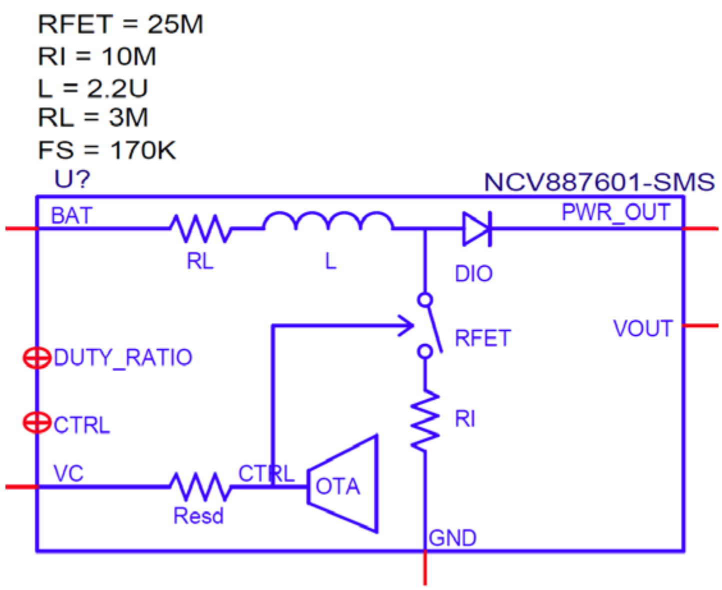

Figure 2 NCV887601 Library Symbol

The following elements have been added to the PWMCM_LX.LIB model to create the NCV887601-SMS.LIB small-signal mode.

- Inductor ESR
- Boost MOSFET transistor RDS(ON)
- Current sense resistor
- The op amp characteristics and feedback voltage divider.
- IC-VOUT input terminal (Note VDRV load must be added externally. Refer to RDRV location in the simulation schematic)
- IC specific controller slope compensation

A stability analysis of the boost converter design may be performed by passing the following parameters to the NCV887601-SMS_revX model:

- RFET – MOSFET RDS(ON) under operating condition (Ω)
- RI – Current Sense resistor (Ω)
- L – Boost inductor value under operating condition (H)
- RL – Boost inductor ESR under operating condition (Ω)
- FS – Converter operating frequency (default value is 170 kHz)

Modeling Example

A PSPICE small-signal analysis implementation of the NCV887601BSTGEVB demo board is shown in Fig. 3. Simulation results are shown in Fig. 4. Node definitions are provided in Table 1. The NCV887601 feedback amplifier is an operational transconductance amplifier (OTA). A 542 Ω resistor between the OTA output and the IC-VC compensation pin is implemented in silicon for ESD protection. To permit an accurate OTA gain analysis when selecting compensation feedback components, the internal OTA output node (“CTRL”) is made available and strictly intended for analysis.

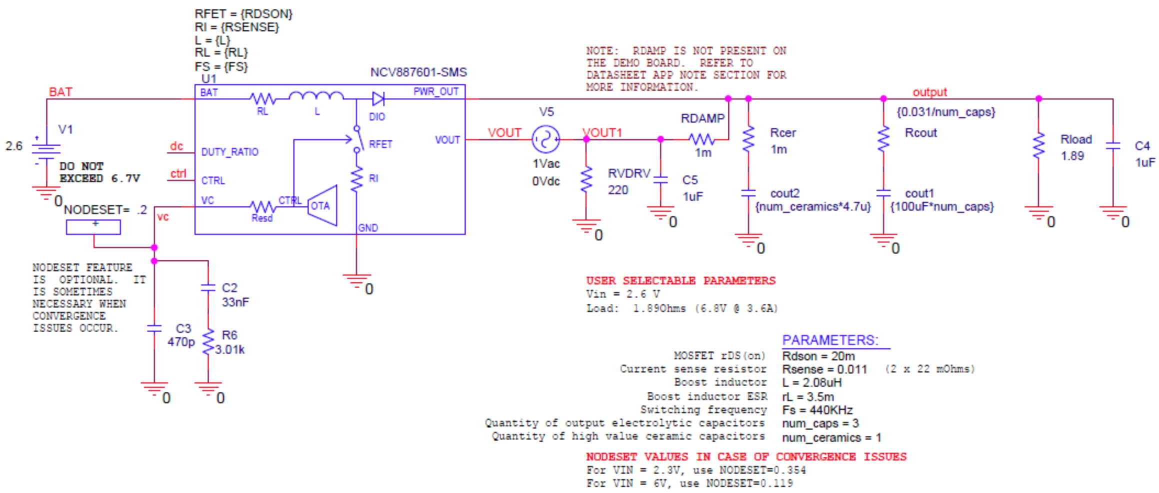

Figure 3 NCV887601BSTGEVB Evaluation Board Small-Signal Simulation Schematic

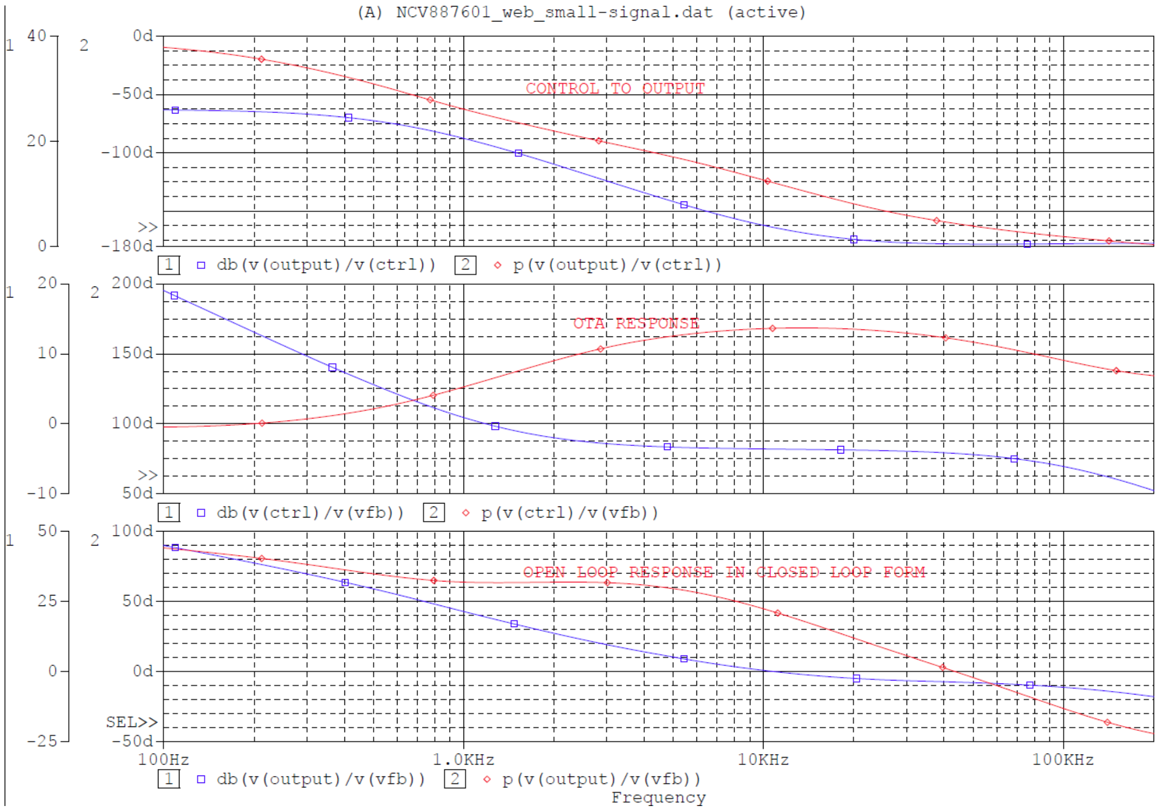

Figure 4 NCV887601BSTGEVB Evaluation Board Small-Signal Simulation Feedback Loop Response

The IC-VOUT pin serves a dual function:

(1) Feedback control

(2) IC-power source.

As a result of this dual function, the actual PCB physical IC-VOUT node cannot be used to perform lab measurements. The feedback loop may only be analyzed by simulation and verified in a lab environment by input line and output transient testing.

Table 1 NCV887601 Model – Node Definitions

Parameter	Monitoring Purposes Only?	Unit	Range	Comment
BAT	No	V	< 6.7 V	Power Supply Input Voltage
DUTY_RATIO	Yes	N/A	0 – 0.83	INTERNAL NODE FOR SIMULATION ANALYSIS
CTRL	Yes	V	N/A	INTERNAL NODE FOR SIMULATION ANALYSIS
VC	No	V	N/A	IC Compensation Pin
PWR_OUT	No	V	Fixed 6.8 V	IC Specific Fixed Regulation Output Voltage
VOUT	No	V	Fixed 6.8 V	IC Feedback Input Voltage
GND	No	V	0 V	Connect to Schematic Ground Reference

Table 2 NCV887601 Model – Parameters Table Definition

Parameter	Unit	Comment
RFET	Ω	MOSFET RDS(ON) (Default Value = 25 mΩ)
RI	Ω	Current Sense Resistor (Default Value = 10 mΩ)
L	H	Boost Inductor (Default Value = 10µH)
rL	Ω	Boost Inductor ESR (Default Value = 3 mΩ)
FS	Hz	Switching Frequency (Default Value = 170 kHz)

Feedback Loop Analysis Methodology

Simulations should be run at worst case parameter conditions (e.g.: Minimum input voltage, worst case output capacitor parasitic ESR values, etc). Additional simulations under less stringent conditions (e.g. nominal ESR, different input voltage conditions) are recommended as well for verification.

1- Control-Output (Modulator Plot) Response

This is the response of the power supply as seen by the IC's internal CTRL node (V(VOUT1)/V(CTRL)). This information is required to select OTA compensation components (R6, C2, C3).

2- OTA Compensation

From the modulator plot data, the OTA compensation network is determined (V(CTRL)/V(VOUT)) by selecting the desired zero gain and frequency values (R6/C2) and pole frequency (C3). CTRL is the OTA output (before Resd) and is a node internal to the IC and is strictly intended for analysis.

3- Loop Response (Open-Loop Response in Closed-Loop Form)

The power supply feedback loop response is obtained by plotting V(OUT1/V(VOUT). The resulting design cross-over frequency, phase-margin and gain-margin are now obtained.

References

[1] C. Basso, "Switch-Mode Power Supplies – SPICE Simulations and Practical Designs", McGraw Hill, 2008.
[2] NCV8876: Automotive Grade Start-Stop Non-Synchronous Boost Controller datasheet: http://onsemi.com/PowerSolutions/product.do?id=NCV8876

[3] NCV887601 Automotive Start Stop Grade Boost Controller Evaluation Board: http://www.onsemi.com/pub_link/Collateral/EVBUM2200-D.PDF