NCV881930, NCV891930

Small-Signal PSPICE Model

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The NCV8x1930MW0X_E_REV 0.LIB library file is a small-signal implementation of the NCV881930MW00 (3.3V and 5 V, 410 kHz), NCV891930MW00 (3.3 V and 5V, 2 MHz) and NCV891930MW01 (3.65 V and 4 V, 2 MHz) low quiescent current automotive synchronous buck controllers intended for feedback loop AC stability analysis (cannot be used for large-signal transient analysis).

The example PSPICE files demonstrate all six voltage model implementations used for the evaluation demo boards (Fig. 1, [5], [6]).

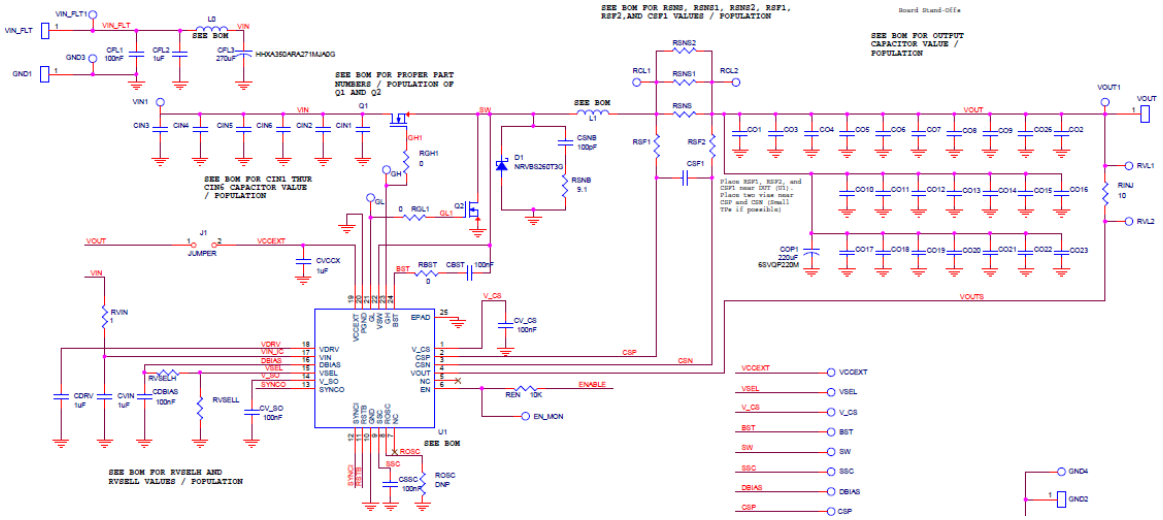

Figure 1 NCV881930MW00 Evaluation Board Schematic

Modeled Elements

This NCV8x1930MW0X_E_REV 0.LIB model is a modification of the public domain current-mode lossy switch PWMCM_LX.LIB model created by Christophe Basso [1]. The corresponding NCV8X1930MW0X_REV 0.OLB symbol representation is shown in Figure 2.

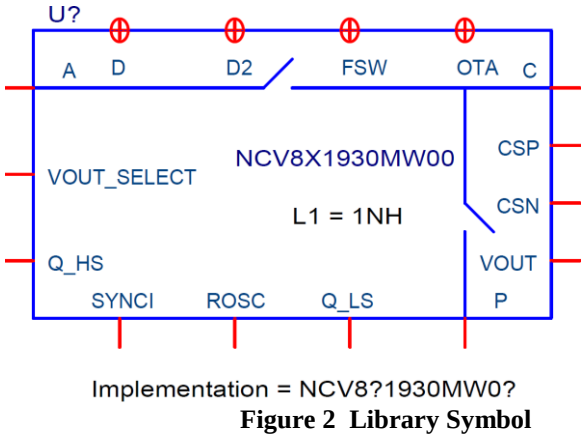

Figure 2 Library Symbol

The following elements have been added to the PWMCM_LX.LIB model to create the NCV8x1930MW0X_E_REV 0.LIB small-signal mode.

- Device type selection.
- The operational transconductance amplifier (OTA) and IC internal compensation network.
- Analysis specific device monitoring nodes (duty ratio D and D', switching frequency FSW, internal OTA output).
- Current sense resistor feedback pins (CSP, CSN).
- The OTA characteristics, compensation and voltage feedback divider.
- IC VOUT_SELECT, VOUT, ROSC, SYNCI pins.
- IC specific controller internal slope compensation.
- VOUT – Connect directly to output voltage node. An external output voltage divider must not be used.

An AC stability analysis of the buck converter design may be performed by passing the following parameters to the NCV8x1930MW0X_E_REV 0.LIB model:

- Implementation = NCV8?1930MW0? – Available options are:
    - NCV8?1930MW0? = NCV881930MW00 (410 kHz, 3.3 V or 5 V)
    - NCV8?1930MW0? = NCV891930MW00 (2 MHz, 3.3 V or 5 V)
    - NCV8?1930MW0? = NCV891930MW01 (2 MHz, 3.65 V or 4 V)
- L1 – Buck inductor value under operating condition (H).

Modeling Example

A PSPICE small-signal analysis implementation of the 5 V/10 A NCV881930MW00 demo board is shown in Fig. 3. Simulation results are shown in Fig. 4. Node definitions are provided in Table 1. The internally compensated feedback error amplifier is an OTA. The node cannot be used to change the feedback loop compensation. It is provided strictly for AC feedback loop analysis.

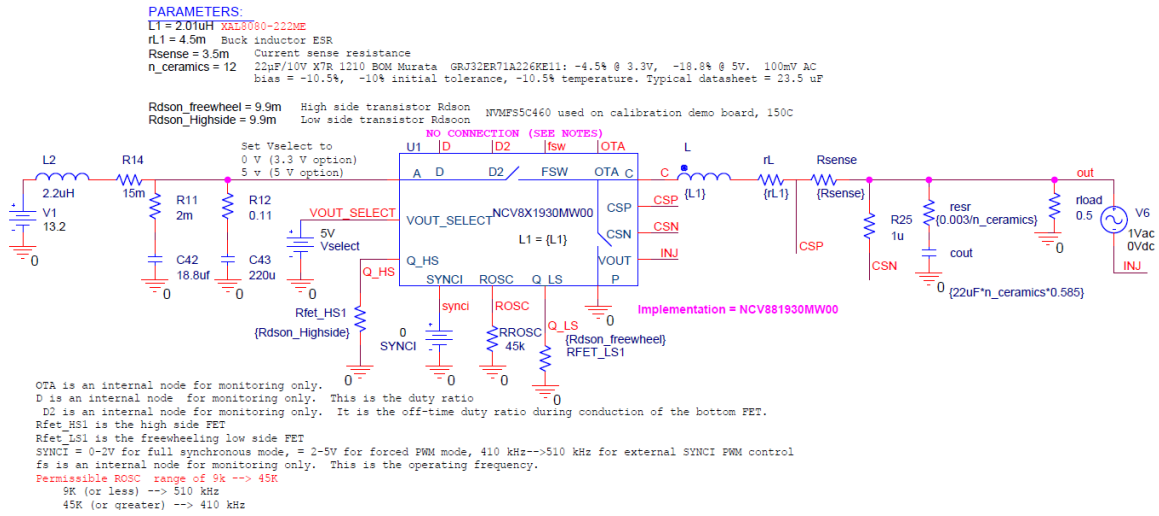

Figure 3 Schematic - NCV881930MW00 5 V/10 A Small-Signal Simulation Example

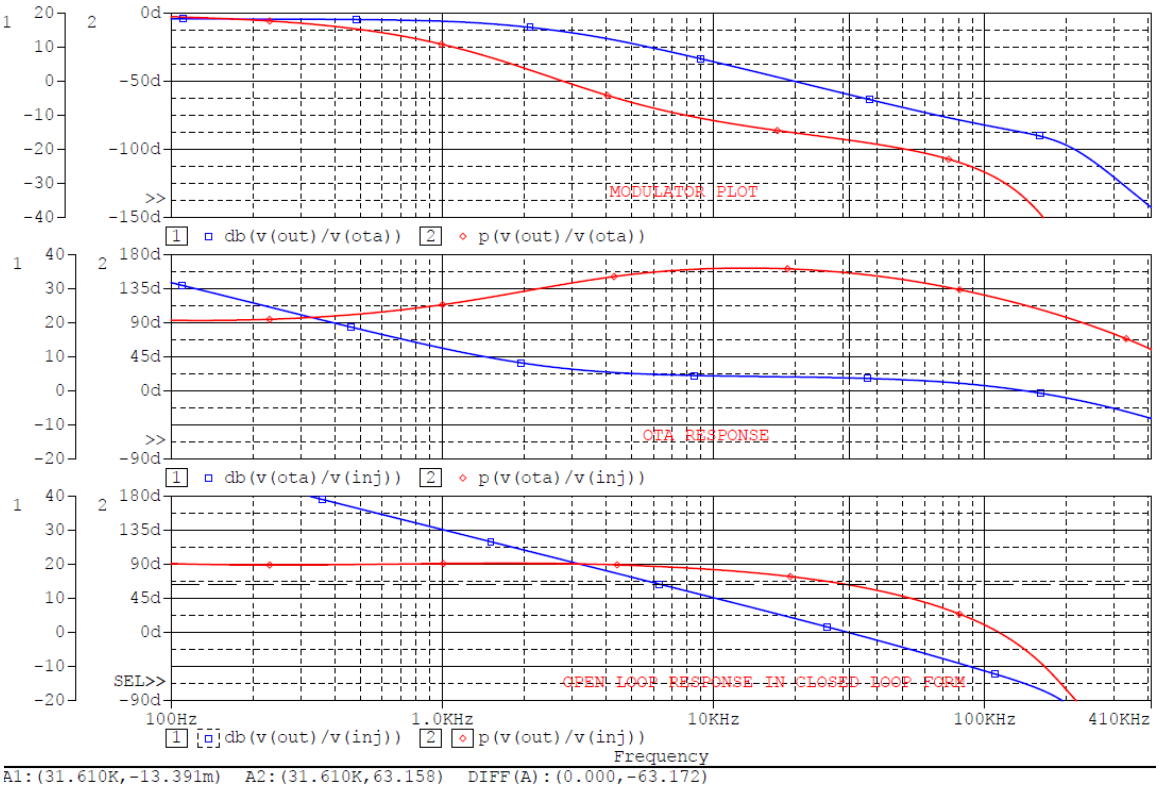

Figure 4 NCV881930MW00 5 V/10 A Small-Signal Simulation Feedback Loop Response

Table 1 provides a comprehensive summary of the functions from the model terminals.

Table 1 NCV881930_891930 Model – Node Definitions

Parameter	Monitoring Purposes Only?	Unit	Range	Comment
D	Yes	N/A	0-1	INTERNAL NODE FOR SIMULATION ANALYSIS.
D2	Yes	N/A	0-1	INTERNAL NODE FOR SIMULATION ANALYSIS.
FSW	Yes	V	410→510 kV or 2→2.5 MV	1 V = 1 Hz.
OTA	Yes	V	N/A	INTERNAL NODE FOR SIMULATION ANALYSIS.
C	No	V	Per VOUT_SELECT	This is a term used in modeling literature to indicate the 'Common' node of the model. Connect to the output filter inductor.
CSP	No	V	CSN + I_{limit}	+ terminal, current sense.
CSN	No	V	N/A	- terminal, current sense.
VOUT	No	V	V	Buck model output voltage/current terminal
P	No	V		This is a term used in modeling literature to indicate the 'Passive' node of the model. Connect to ground.
Q_LS	No	Ω		Low side MOSFET R_{DS}(ON) under VGS = 4.5 V operating condition.
ROSC	No	Ω		Optional. When used, a resistor in the range of 9 kΩ → 45 kΩ will set the operating frequency (refer to datasheet to select a value). - ROSC < 9 kΩ will default switching frequency to that of 9 kΩ. - ROSC > 45 kΩ will default switching frequency to that of 45 kΩ.
SYNCI	No	V	0, 5, external frequency	0-2 V→Pulse skip mode enabled*. 2-5V→ Fully synchronous mode. External frequency→user selectable frequency within device specific permissible datasheet operating range.
Q_HS	No	Ω		High side VGS = 5 V MOSFET R_{DS}(ON) under operating condition.
VOUT_SELECT	No	V	0, 5	Device voltage option selection.
A	No	V	~6→37	This is a term used in modeling literature to indicate the 'Active' node of the model. Connect to the input voltage.

* This model cannot be used to establish pulse skipping feedback loop information. The IC's pulse skipping operation is a hysteretic type operating mode in which the OTA feedback loop compensation is disabled.

Table 2 NCV881930_891930 Model – Parameters Table Definition

Parameter	Unit	Comment
L1	H	Buck output inductor (default value = 1 nH)

Feedback Loop Analysis Methodology

Simulations should be run at worst case parameter conditions. 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 OTA control node (V(VOUT)/V(OTA)).

2- OTA Compensation

The OTA compensation network is determined by monitoring V(OTA)/V(INJ). OTA is a node internal to the IC which is not user accessible. It is intended strictly for analysis purposes.

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

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

Bandwidth and phase margin may only be adjusted via the selection of appropriate output inductor and filter capacitors. Output filtering components recommendations may be found in the product datasheets ([2], [3]) and product application note [4].

References

[1] C. Basso, "Switch-Mode Power Supplies – SPICE Simulations and Practical Designs", McGraw Hill, 2008.

[2] NCV881930: Low Quiescent Current 410 kHz Automotive Synchronous Buck Controller: http://www.onsemi.com/PowerSolutions/product.do?id=NCV881930

[3] NCV891930: Low Quiescent Current 2 MHz Automotive Synchronous Buck Controller: http://www.onsemi.com/PowerSolutions/product.do?id=NCV891930

[4] NCV881930/NCV891930 - Mixed Technology Capacitor Filtering: http://www.onsemi.com/PowerSolutions/supportDoc.do?type=AppNotes&rpn=NCV891930

[5] NCV881930 5 V/10 A Low Quiescent Current 410 kHz Buck Controller Evaluation Board: http://www.onsemi.com/pub_link/Collateral/TBD-D.PDF

[6] NCV891930 5 V/6 A Low Quiescent Current 2 MHz Buck Controller Evaluation Board: http://www.onsemi.com/pub_link/Collateral/TBD-D.PDF