

# NCV8851BDBGEVB

## NCV8851B Automotive Grade Synchronous Buck Controller Evaluation Board User's Manual



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### EVAL BOARD USER'S MANUAL

#### Description

The NCV8851B Evaluation Board provides a convenient way to evaluate and integrate a complete high-efficiency synchronous buck converter design. No additional components are required, other than dc supplies for the input voltage and enable pin. The board also can be connected to an external clock source to synchronize the switching frequency or for spread spectrum operation. The board is configured for a 5.0 V output with a 170 kHz switching frequency and a 4 A current limit, intended for applications requiring over 3 A of current.

Additionally, modifying the NCV8851B Evaluation Board for different output voltage, switching frequency or current limit is straightforward, requiring minimal component changes.

#### Key Features

- 5.0 V Output Voltage
- 91% Efficiency at 3 A
- 4 A Average Current Limit (ACL)
- 170 kHz Switching Frequency
- Average Current Mode Control
- Automotive Grade for up to  $T_A = 105^\circ\text{C}$
- Wide Input Voltage Range of 4.5 V to 40 V
- Regulates through Load Dump Conditions
- 1.0  $\mu\text{A}$  Maximum Quiescent Current in Sleep Mode
- Programmable Fixed Frequency – 170 kHz to 500 kHz
- External Clock Synchronization up to 600 kHz
- Easy to Modify for Other Applications

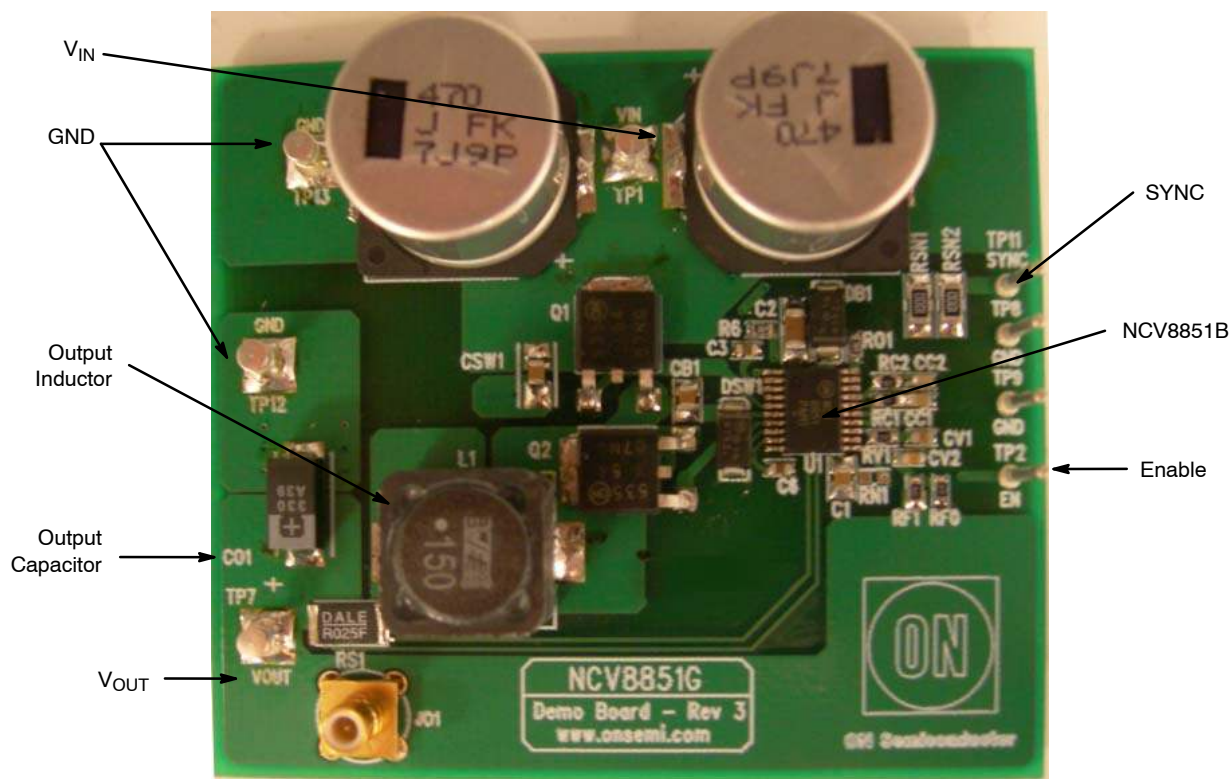


Figure 1. NCV8851B Evaluation Board

# NCV8851BDBGVB

**Table 1. EVALUATION BOARD TERMINAL DESCRIPTIONS**

Terminal	Function
V <sub>IN</sub>	Positive dc input voltage.
GND	Common dc return.
V <sub>OUT</sub>	Regulated dc output voltage.
SYNC	Input for external clock synchronization.
EN	Enable input. When disabled, the part enters sleep mode.

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

Rating	Value	Unit
Dc Supply Voltage (V <sub>IN</sub> , EN) Peak Transient Voltage (Load Dump)	-0.3 to 40 45	V
Dc Supply Voltage (SYNC)	-0.3 to 7	V
Junction Temperature (NCV8851B)	-40 to 150	°C
Ambient Temperature (Demo board)	-40 to 105	°C

Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.

**Table 3. ELECTRICAL CHARACTERISTICS** (T<sub>A</sub> = 25°C, 4.5 V ≤ V<sub>IN</sub> ≤ 40 V, I<sub>OUT</sub> ≤ 4 A, unless otherwise specified)

Characteristic	Conditions	Typical Value	Unit
<b>OUTPUT VOLTAGE</b>			
Output Voltage	-	5.00	V
Voltage Accuracy	-	4	%
Line Regulation	I <sub>OUT</sub> = 0 A	0.02	%
Load Regulation	V <sub>IN</sub> = 13.2 V	0.04	%
<b>SWITCHING REGULATOR</b>			
Switching Frequency	V <sub>IN</sub> = 13.2 V, I <sub>OUT</sub> = 0 A	170	kHz
Soft-start Time	V <sub>IN</sub> = 13.2 V, I <sub>OUT</sub> = 100 mA, 10-90%	14	ms
SYNC Frequency	-	170 to 600	kHz
Duty Cycle Range	-	5 to 95	%
<b>CURRENT LIMIT</b>			
Average Current Limit	-	4	A
Cycle-by-cycle Overcurrent Protection	-	6.4	A
<b>GENERAL</b>			
Input Undervoltage Lockout (UVLO)	V <sub>IN</sub> increasing	4.3	V
Efficiency	V <sub>IN</sub> = 13.2 V, I <sub>OUT</sub> = 100 mA V <sub>IN</sub> = 13.2 V, I <sub>OUT</sub> = 1 A V <sub>IN</sub> = 13.2 V, I <sub>OUT</sub> = 4 A	70.7 93.2 90.9	%
Maximum Shutdown Current	-	1.0	μA
Thermal Shutdown	-	180	°C

# NCV8851BDBGVVB

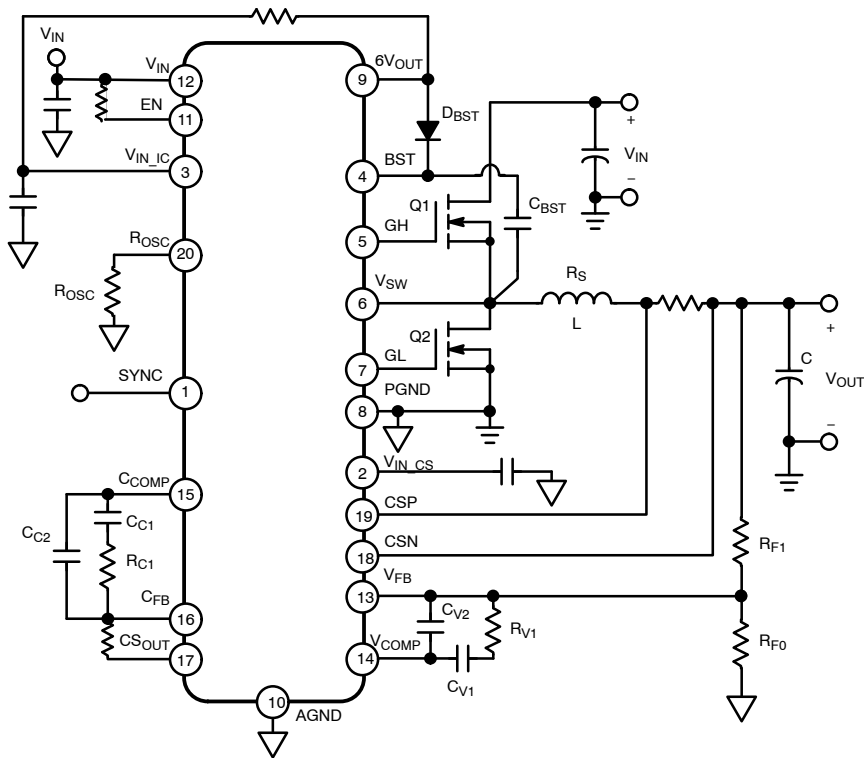


Figure 2. NCV8851B Application Diagram

## Operational Guidelines

1. Connect a dc input voltage,  $4.5 \text{ V} \leq V_{\text{BATT}} \leq 40 \text{ V}$ , between “ $V_{\text{IN}}$ ” and “ $\text{GND}$ ”.
2. Connect a load impedance between “ $V_{\text{OUT}}$ ” and “ $\text{GND}$ ”.
3. Connect a dc enable voltage,  $4.5 \text{ V} \leq \text{EN} \leq V_{\text{BATT}} \leq 20 \text{ V}$ , between “ $\text{EN}$ ” and “ $\text{GND}$ ”. If  $\text{EN}$  must be tied to a higher voltage, a current limiting resistor is required (see below).
4. Optionally, for external clock synchronization, connect a pulse source,  $\text{SYNC}$ , between “ $\text{SYNC}$ ” and “ $\text{GND}$ ”. The positive amplitude should be  $1.0 \text{ V} \leq \text{SYNC} \leq 7.0 \text{ V}$  and negative amplitude should be  $-0.3 \text{ V} \leq \text{GND} \leq 0.8 \text{ V}$ .  $\text{SYNC}$  pulse duty cycle may range from 10% to 90%, and frequency may range from the programmed frequency (170 kHz by default) to 600 kHz.

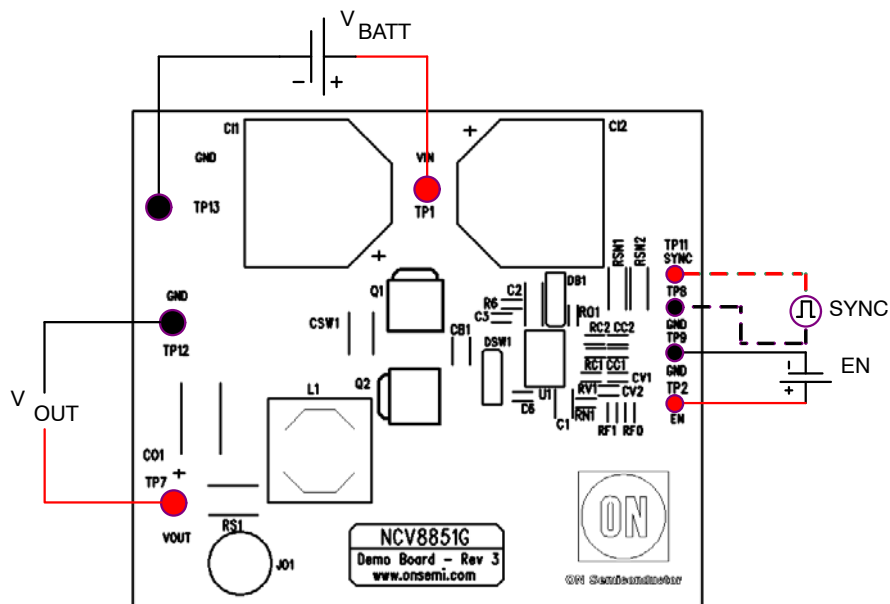


Figure 3. Evaluation Board Connections

# NCV8851BDBGVB

## TYPICAL WAVEFORMS

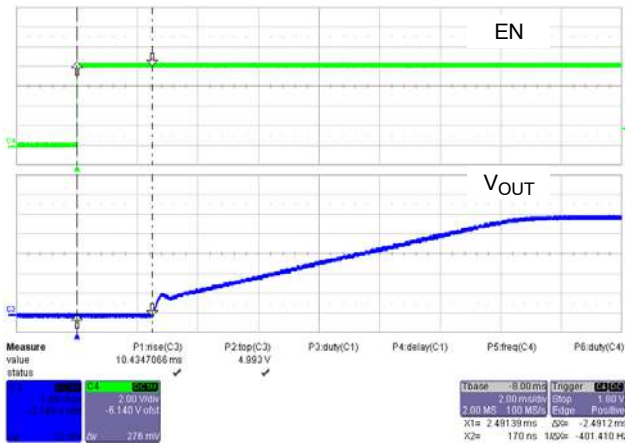


Figure 4. Startup at 170 kHz, 13.2 V to 5 V Output

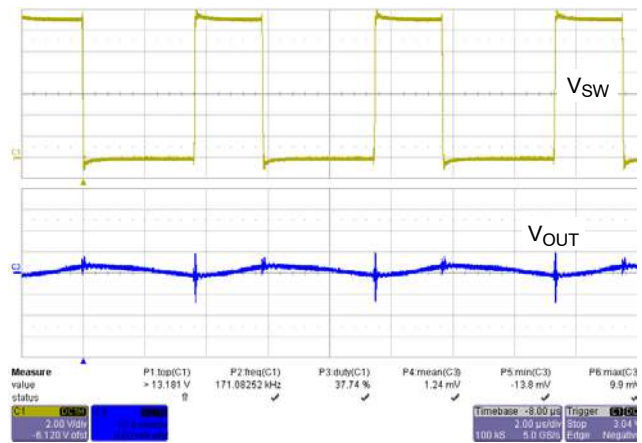


Figure 5. S<sub>WN</sub>, V<sub>OUT</sub> at 170 kHz, 13.2 V to 5 V Output

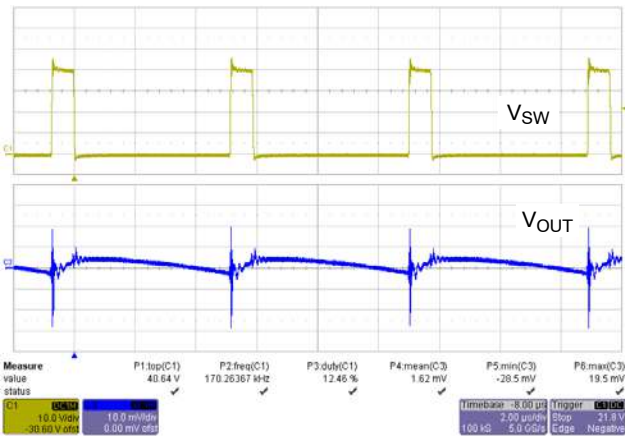


Figure 6. Minimum Duty Cycle at 170 kHz, 5 V Output

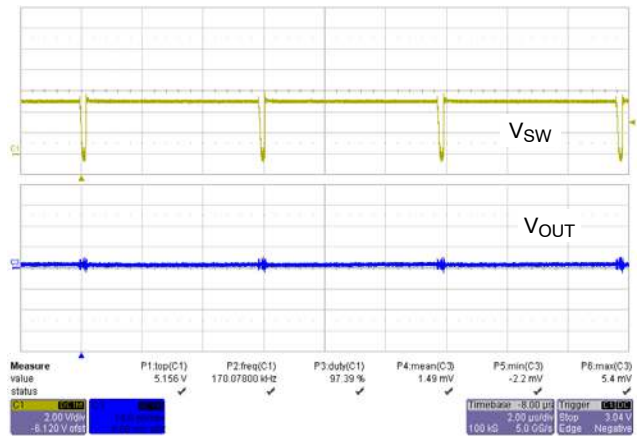


Figure 7. Maximum Duty Cycle at 170 kHz, 5 V Output

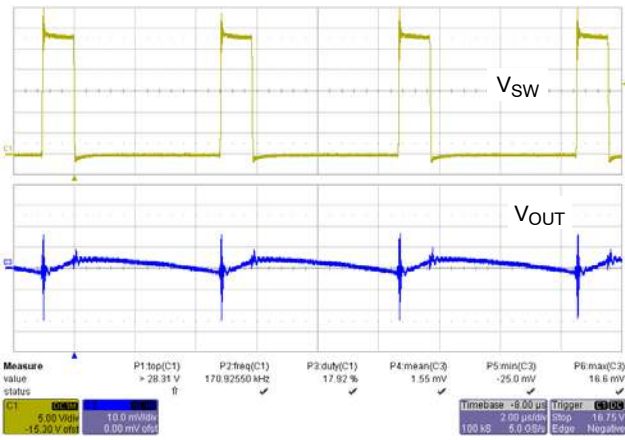


Figure 8. S<sub>WN</sub>, V<sub>OUT</sub> at 170 kHz, 28 V to 5 V Output

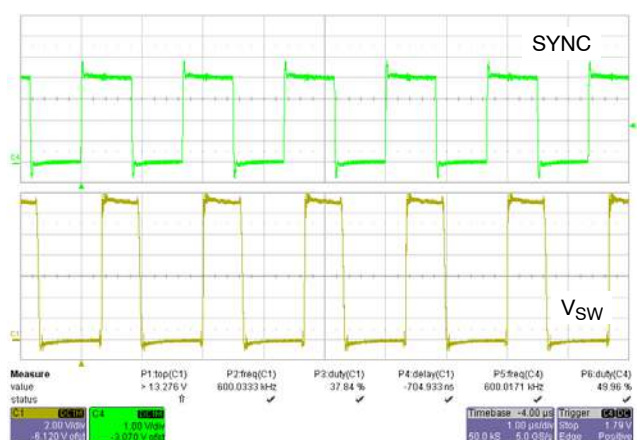


Figure 9. SYNC from 170 to 600 kHz, 13.2 V to 5 V Output

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## TYPICAL PERFORMANCE

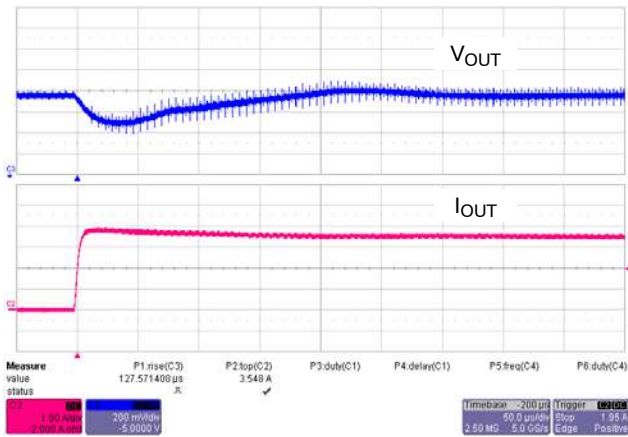


Figure 10. 100 mA to 3.6 A Load Step, 170 kHz, 5 V Output

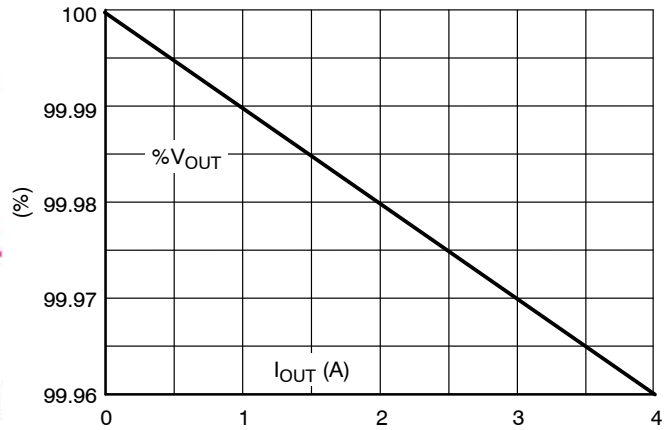


Figure 11. 100 mA to 3.6 A Load Step, 170 kHz, 5 V Output

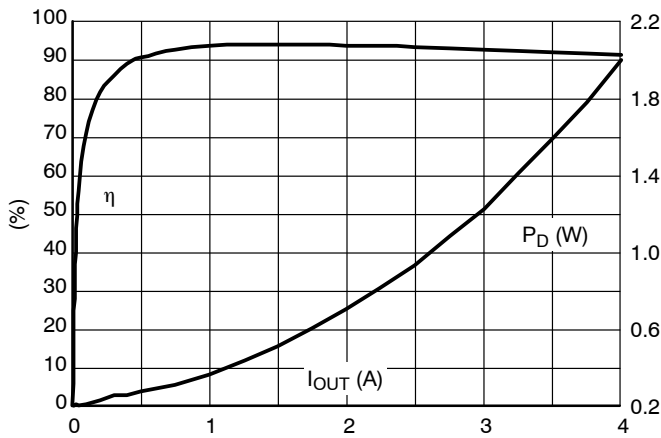


Figure 12. Efficiency at 170 kHz, 13.2 V to 5 V Output

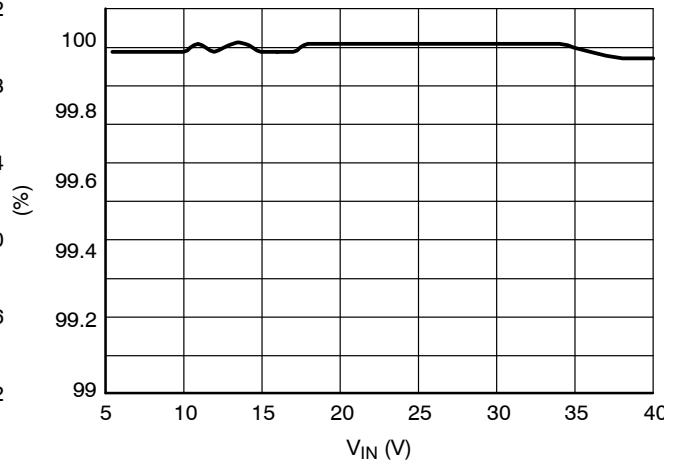


Figure 13. Line Regulation at 170 kHz, 13.2 V to 5 V Output

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## SCHEMATIC

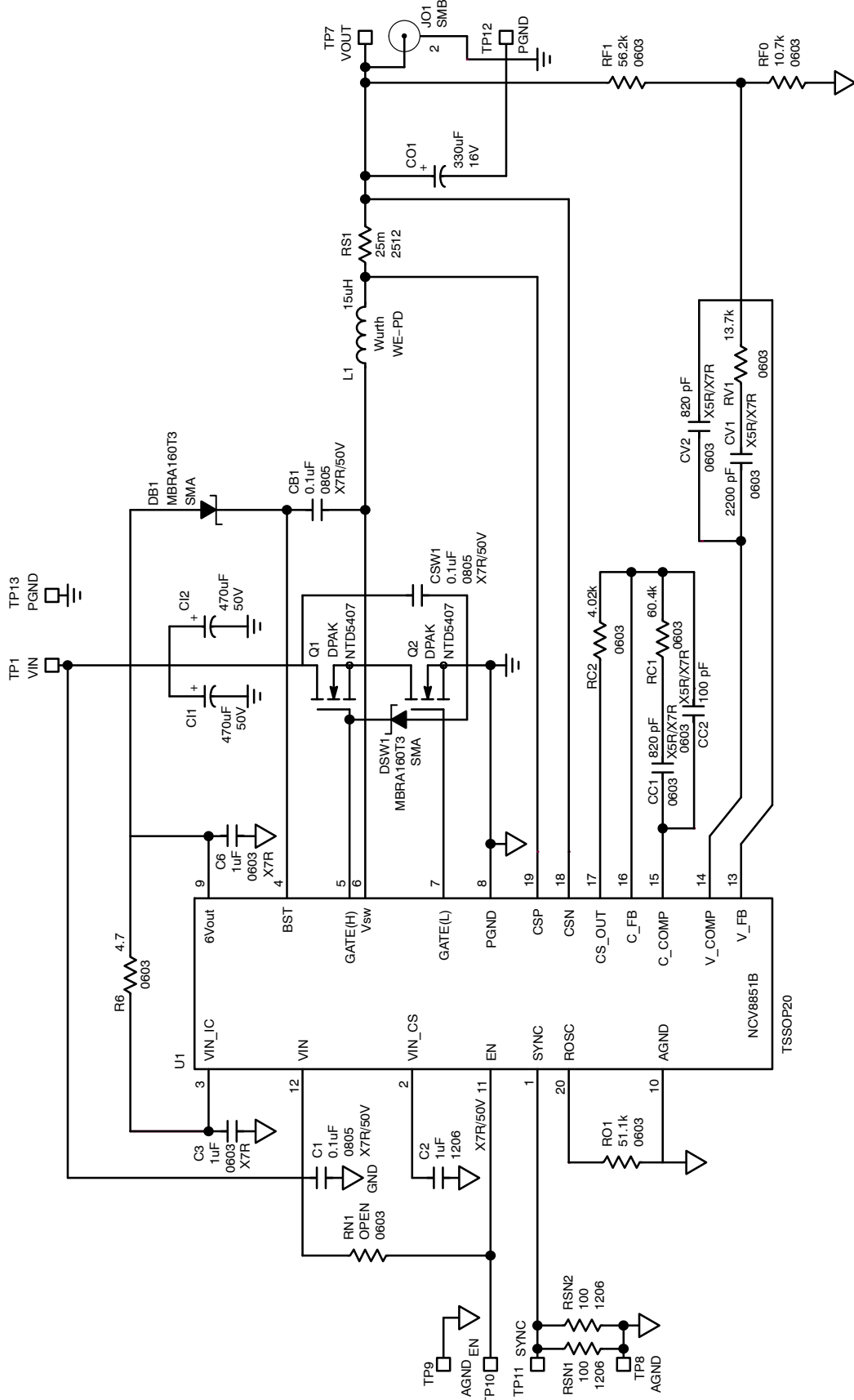


Figure 14. NCV8851B Evaluation Board Schematic

# NCV851BDBGVB

**Table 4. BILL OF MATERIALS**

Qty	Ref	Part	Part Description	Manufacturer	Part Number
3	CSW1	0.1 $\mu$ F	0.1 $\mu$ F 50V 10% 0805 X7R ceramic SMD capacitor	Kemet	C0805C104K5RACTU
	CB1	0.1 $\mu$ F	0.1 $\mu$ F 50V 10% 0805 X7R ceramic SMD capacitor	Kemet	C0805C104K5RACTU
	C1	0.1 $\mu$ F	0.1 $\mu$ F 50V 10% 0805 X7R ceramic SMD capacitor	Kemet	C0805C104K5RACTU
2	CC1	820pF	820pF 10% 0603 X7R ceramic SMD capacitor	Murata Electronics North America	GRM188R71H821KA01D
	CV2	820pF	820pF 10% 0603 X7R ceramic SMD capacitor	Murata Electronics North America	GRM188R71H821KA01D
1	CC2	100pF	820pF 10% 0603 X7R ceramic SMD capacitor	Murata Electronics North America	GCM1885C1H101JA16D
2	CI1	470 $\mu$ F	470 $\mu$ F 63V FK electrolytic SMD capacitor	Panasonic - ECG	EEVFK1J471M
	CI2	470 $\mu$ F	470 $\mu$ F 63V FK electrolytic SMD capacitor	Panasonic - ECG	EEVFK1J471M
1	CO1	330 $\mu$ F	330 $\mu$ F 10V 20% polymer electrolytic SMD capacitor	Sanyo Electronic Components Co.	10TPE330M
1	CV1	2200pF	2200pF 10% 0603 X7R ceramic SMD capacitor	Panasonic - ECG	ECJ-1VB1H222K
1	C2	1 $\mu$ F	1 $\mu$ F 50V 10% 1206 X7R ceramic SMD capacitor	Murata Electronics North America	GCM31MR71H105KA55L
2	C3	1 $\mu$ F	1 $\mu$ F 16V 10% 0603 X7R ceramic SMD capacitor	Taiyo Yuden	EMK107BJ105KA-TR
	C6	1 $\mu$ F	1 $\mu$ F 16V 10% 0603 X7R ceramic SMD capacitor	Taiyo Yuden	EMK107BJ105KA-TR
2	DSW1	MBRA160T3	1A, 60 V Schottky SMD rectifier	ON Semiconductor	MBRA160T3G
	DB1	MBRA160T3	1A, 60 V Schottky SMD rectifier	ON Semiconductor	MBRA160T3G
1	JO1	SMB	Vertical PCB mount gold RF connector jack	Emerson Network Power Connectivity Solutions	131-3701-261
1	L1	15 $\mu$ H	15 $\mu$ H SMD power inductor	Würth	7447709150
2	Q1	NTD5407	40V, 38A N-channel power MOSFET	ON Semiconductor	NTD5407NG
	Q2	NTD5407	40V, 38A N-channel power MOSFET	ON Semiconductor	NTD5407NG
1	RC1	60.4k	60.4k $\Omega$ 1% 0.1W 0603 Thick-film SMD resistor	Yageo Corporation	RC0603FR-0760K4L
1	RC2	4.02k	4.02k $\Omega$ 1% 0.1W 0603 Thick-film SMD resistor	Yageo Corporation	RC0603FR-074K02L
1	RF0	10.7k	10.7k $\Omega$ 1% 0.1W 0603 Thick-film SMD resistor	Yageo Corporation	RC0603FR-0710K7L
1	RF1	56.2k	56.2k $\Omega$ 1% 0.1W 0603 Thick-film SMD resistor	Yageo Corporation	RC0603FR-0756K2L
1	RN1	OPEN	1% 0.1W 0603 Thick-film SMD resistor		
1	RO1	51.1k	51.1k $\Omega$ 1% 0.1W 0603 Thick-film SMD resistor	Yageo Corporation	RC0603FR-0751K1L
2	RSN1	100	100 $\Omega$ 1% 0.25W 1206 Thick-film SMD resistor	Yageo Corporation	RC1206FR-07100RL
	RSN2	100	100 $\Omega$ 1% 0.25W 1206 Thick-film SMD resistor	Yageo Corporation	RC1206FR-07100RL

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**Table 4. BILL OF MATERIALS**

Qty	Ref	Part	Part Description	Manufacturer	Part Number
1	RS1	25m	25mΩ 1% 2512 Thick-film SMD current sense resistor	Vishay/Dale	WSL2512R0250FEA
1	RV1	13.7k	13.7kΩ 1% 0.1W 0603 Thick-film SMD resistor	Yageo Corporation	RC0603FR-0713K7L
1	R6	4.7	4.75Ω 1% 0.1W 0603 Thick-film SMD resistor	Yageo Corporation	RC0603FR-074R75L
4	TP1	VCC	0.291" X 0.109" Solder terminal turret Ag over Cu	Mill-Max Manufacturing Corporation	2501-2-00-44-00-00-07-0
	TP7	VOUT	0.291" X 0.109" Solder terminal turret Ag over Cu	Mill-Max Manufacturing Corporation	2501-2-00-44-00-00-07-0
	TP12	PGND	0.291" X 0.109" Solder terminal turret Ag over Cu	Mill-Max Manufacturing Corporation	2501-2-00-44-00-00-07-0
	TP13	PGND	0.291" X 0.109" Solder terminal turret Ag over Cu	Mill-Max Manufacturing Corporation	2501-2-00-44-00-00-07-0
4	TP8	AGND	0.042" Inboard pin	Vector Electronics	K24C
	TP9	AGND	0.042" Inboard pin	Vector Electronics	K24C
	TP10	EN	0.042" Inboard pin	Vector Electronics	K24C
	TP11	SYNC	0.042" Inboard pin	Vector Electronics	K24C
1	U1	NCV8851B	Automotive synchronous buck controller	ON Semiconductor	NCV8851BG

## EVALUATION BOARD MODIFICATIONS

### Connecting EN to a Higher Voltage or $V_{BATT}$

Typically, EN is tied to a logic output or low-voltage supply. However, EN can be tied to a higher voltage or to  $V_{BATT}$ . In either case, if the supply that EN is tied to is expected to go above 20 V, a current limiting resistor is required.

For convenience, RN1 is unpopulated, disconnecting EN from  $V_{BATT}$  (via  $V_{IN}$ ) by default. To connect EN to  $V_{BATT}$ , populate RN1 with a current limiting resistor. To connect EN to a separate higher voltage supply from  $V_{BATT}$ , place a current limiting resistor in series with the supply. Consult the data sheet, NCV8851B/D, for selecting a current limiting resistor.

### Programming the Switching Frequency to a Different Value

The switching frequency is programmed with a resistor, RO1, from the  $R_{OSC}$  pin to GND. By default, the switching frequency is set to 170 kHz with a 51.1 kΩ resistor used for RO1. The frequency can be programmed to a different value by replacing RO1. Consult the data sheet, NCV8851B/D, for selecting a different frequency program resistor.

Changing the switching frequency may impact dynamic characteristics. Typically, increasing the switching frequency allows the dynamic response to improve by further optimization of the compensators; however, it is advised to analyze dynamic response results of simulation whenever the switching frequency is modified.

### Synchronizing to a Higher Frequency

When connecting the SYNC input to a significantly higher frequency than that set by the program resistor, dynamic performance could be impaired. Based on empirical results, it is advised to analyze dynamic response results of simulation whenever SYNC is more than 33% higher than the programmed switching frequency.

### Adjusting the Current Limit

The current limit can be adjusted by using a different sense resistor for RS1. Consult the data sheet, NCV8851B/D, for selecting a different current limit.

Changing the sense resistor may impact dynamic characteristics. It is advised to analyze dynamic response results of simulation whenever the sense resistor is modified.



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**Table 5. BOM VARIATIONS**

The following list of BOM variations on output voltage and switching frequency have been tested.

Part	3.3 V, 4 A			5 V, 4 A			8 V, 4 A			Unit
	170kHz	360 kHz	500 kHz	170kHz	360 kHz	500 kHz	170 kHz	360 kHz	500 kHz	
RO1	51.1	23.2	16.2	51.1	23.2	16.2	51.1	23.2	16.2	kΩ
L1	15	10	10	15	15	10	22	15	15	μH
CO1	330	330	330	330	330	330	330	330	330	μF
RS1	25	25	25	25	25	25	25	25	25	mΩ
RC1	60.4	60.4	60.4	60.4	60.4	60.4	60.4	60.4	60.4	kΩ
RC2	4.02	4.02	4.02	4.02	4.02	4.02	4.02	4.02	4.02	kΩ
CC1	820	820	820	820	820	820	820	820	820	pF
CC2	100	100	100	100	100	100	100	100	100	pF
RV1	13.7	27.4	27.4	13.7	27.4	27.4	13.7	13.7	13.7	kΩ
RF0	17.4	17.4	8.66	10.7	5.36	3.57	10.0	4.99	3.32	kΩ
RF1	54.9	54.9	27.4	56.2	28	18.7	90.9	45.3	30.1	kΩ
CV1	2200	2200	2200	2200	2200	2200	2200	2200	2200	pF
CV2	820	820	820	820	820	820	820	820	820	pF

Selection of components for different operational configurations than those listed above is beyond the scope of this document and the data sheet, NCV8851B/D, should

be consulted. Additionally, it is advised to analyze dynamic response results of simulation whenever variant components are used.

# NCV8851BDBGVB

## LAYOUT PLOTS

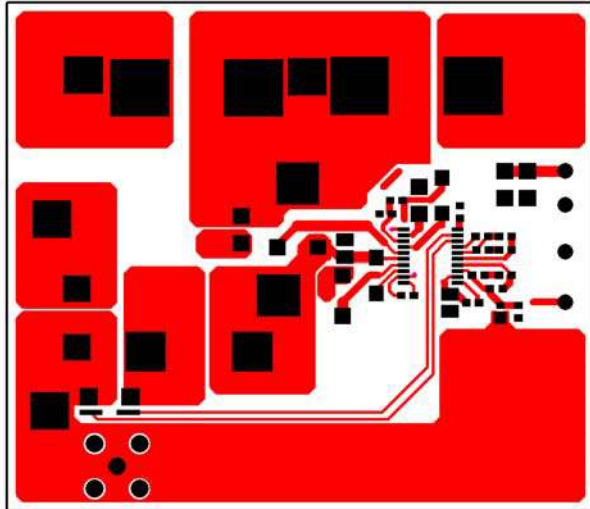
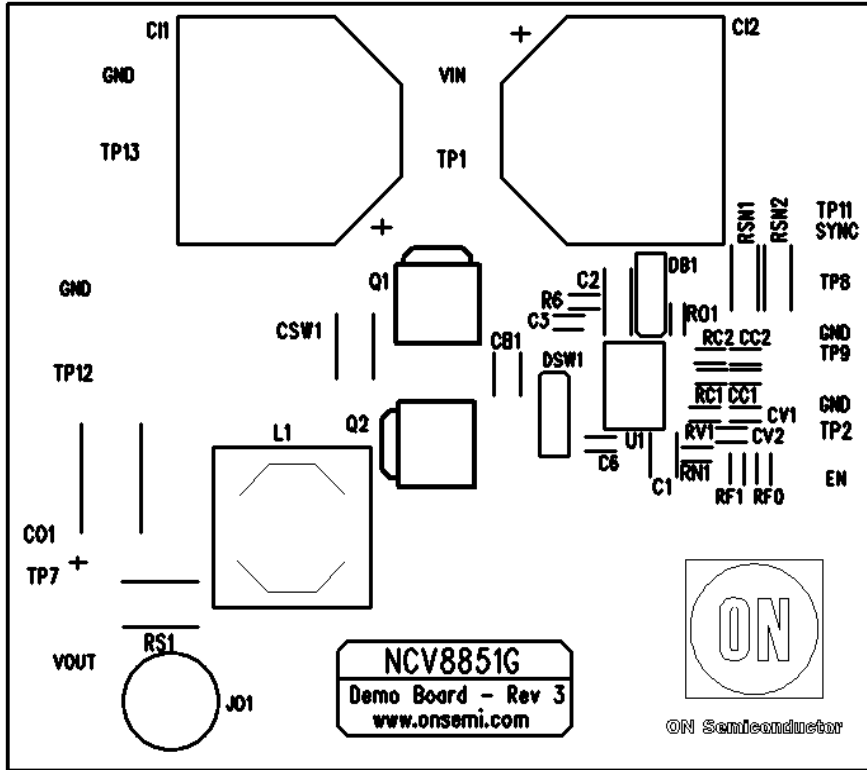


Figure 16. Top Copper

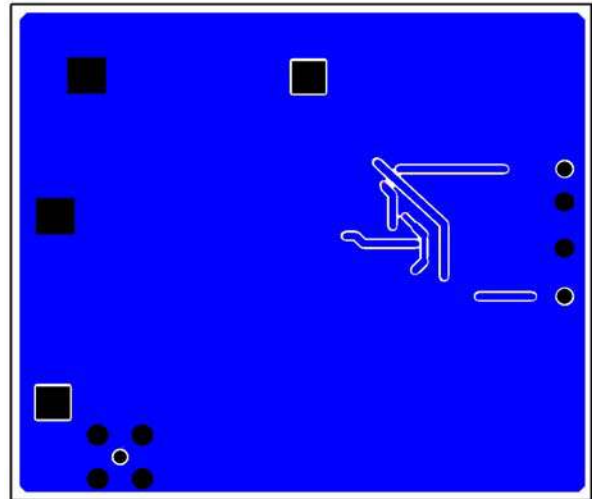



Figure 17. Bottom Copper

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