

24 W Automotive 340 kHz Sepic Converter, NCV887103, Only Ceramic Capacitors

TND6472/D

Overview

This automotive reference design describes the operation and performance of a 24 W automotive Sepic Converter, based on the [NCV887103](#) boost controller with the [NVTFS5C680NL](#) 80 V N-channel MOSFET in 3.3x3.3 WDFN8 package and the [NRVBS360](#) 60 V Schottky diode in SMB package. The reference design highlights the capabilities of the [NCV887103](#) boost controller and shows a complete design for an automotive regulator for a broad range of applications like general purpose pre-regulation, satellite camera supply for ADAS ECU and gate drivers. It is intended for the power supply designer to adopt the circuit directly into a typical system design, making only minimal component changes based on system requirements. The design is meant to be a complete solution, providing access to key features of the [NCV887103](#). Due to the Sepic topology the converter has a true short circuit protection, which is not the case for a boost converter. Special about this design is that it uses only ceramic capacitors which improves lifetime and reliability.

Key Features

- Complete Automotive Reference Design
- Sepic Converter with an Input Voltage Range of 10.0 to 16.0 V
- 340 kHz Switching Frequency for High Efficiency
- onsemi [NCV887103](#) Boost Controller, [NVTFS5C680NL](#) 80 V N-channel MOSFET, [NRVBS360](#) 60 V Schottky Diode
- Small Form Factor PCB with Four Layers
- Using Only Ceramic Capacitors to Maximize Lifetime and Reliability

Table 1. SPECIFICATIONS

Device	NCV887103
Application	Satellite Camera Supply, Gate Driver Supply, Pre-Regulation
Topology	Non-Synchronous Sepic
Isolation	Non-Isolated
Input Voltage	10.0 to 16.0 V
Output Voltage	16.0 V
Output Current	1.5 A
Output Power	24.0 W

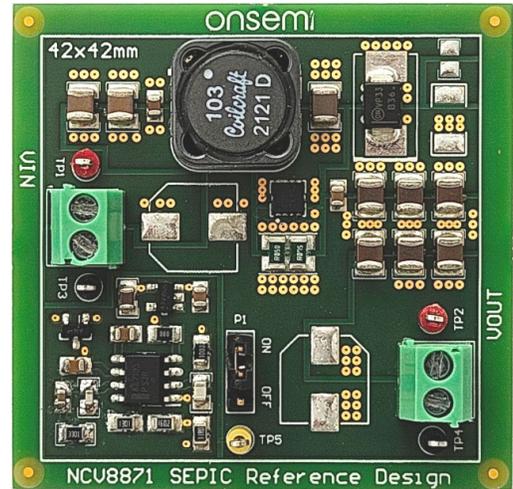


Figure 1. Reference Design Board Image

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SCHEMATIC

Figure 2 shows the schematic of the Sepic converter. LDO U2 (NCV4295C) is used only to enable the converter.

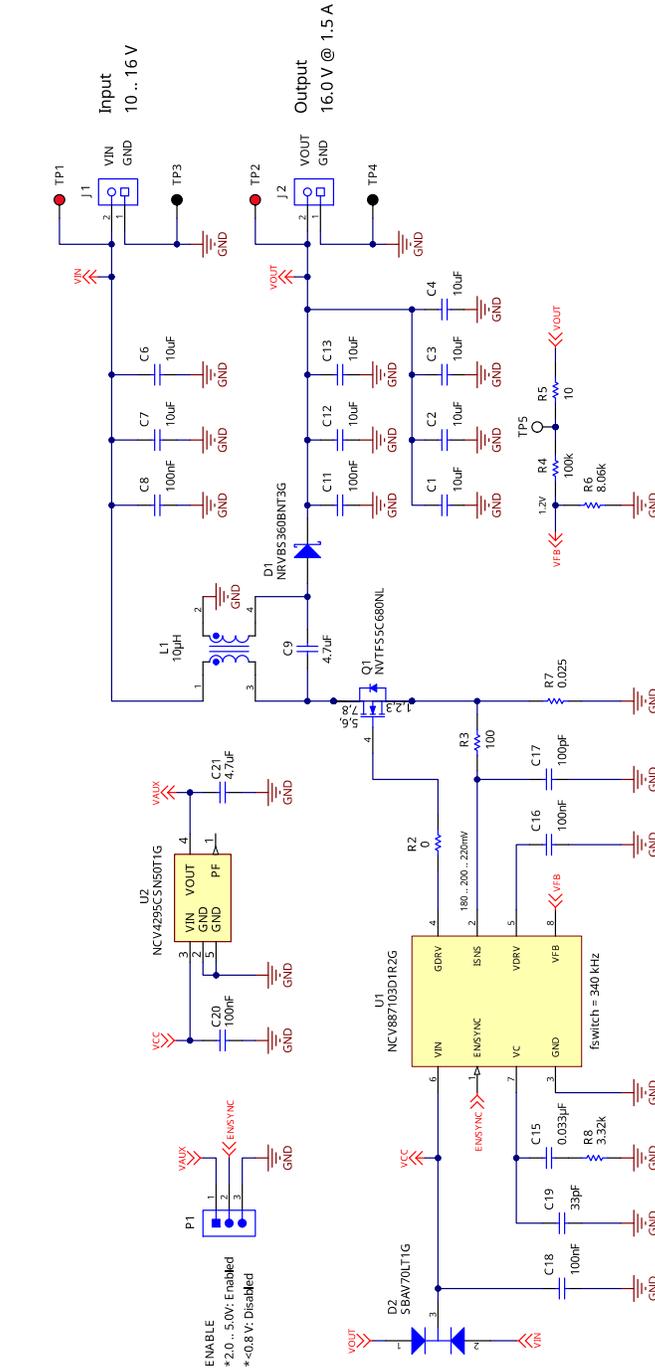


Figure 2. NCV887103 Sepic Schematic

BOARD LAYOUT

Figures 3, 4, 5 and 6 show the top and bottom assembly and the four layers of the PCB. The converter size is 42 mm x 42 mm where the height of the PCB is approximately 10 mm.

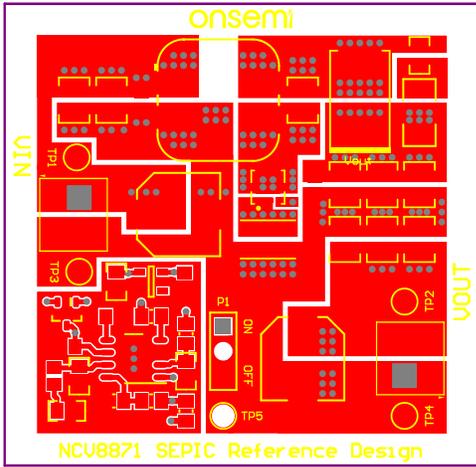


Figure 3. Top Layer and Assembly Drawing

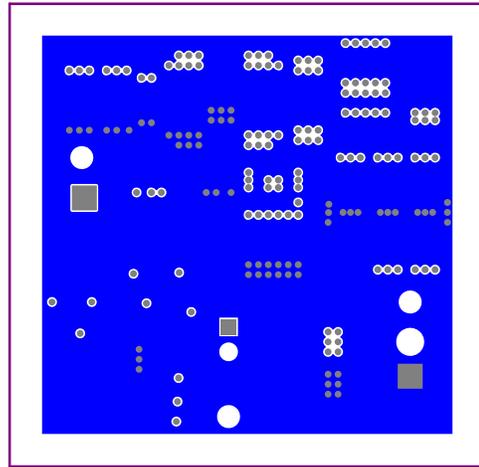


Figure 4. Bottom Layer and Assembly Drawing

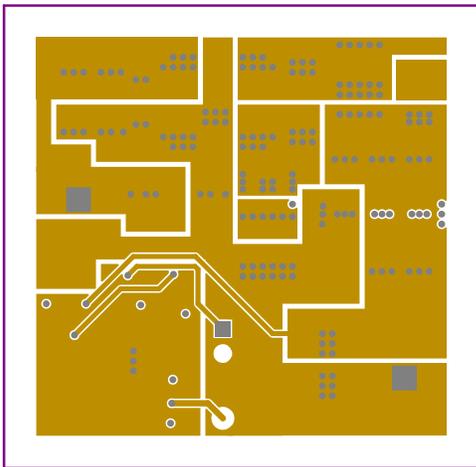


Figure 5. Inner 1 Layer

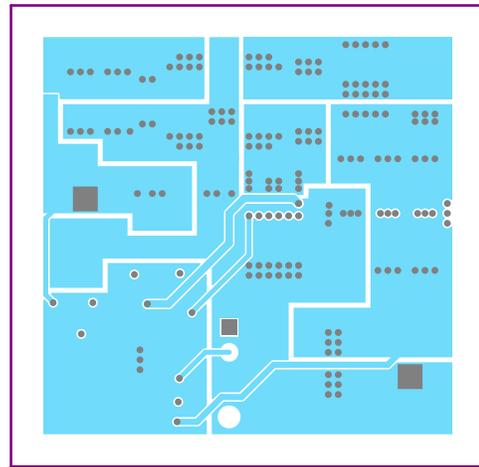


Figure 6. Inner 2 Layer

PERFORMANCE SUMMARY

Output Voltage

The output voltage is set to 16.0 V by an external resistor divider. By changing the ratio of the voltage divider (R4, R6) the output voltage can be changed, considering a reference voltage of 1.2 V. When changing the output voltage, the

current and voltage stress of the components need to be checked as well as the compensation of the error amplifier to ensure reliable and stable operation.

Efficiency

The efficiency for 10.0 V, 12.0 V and 14.0 V input voltage is shown in Figure 7.

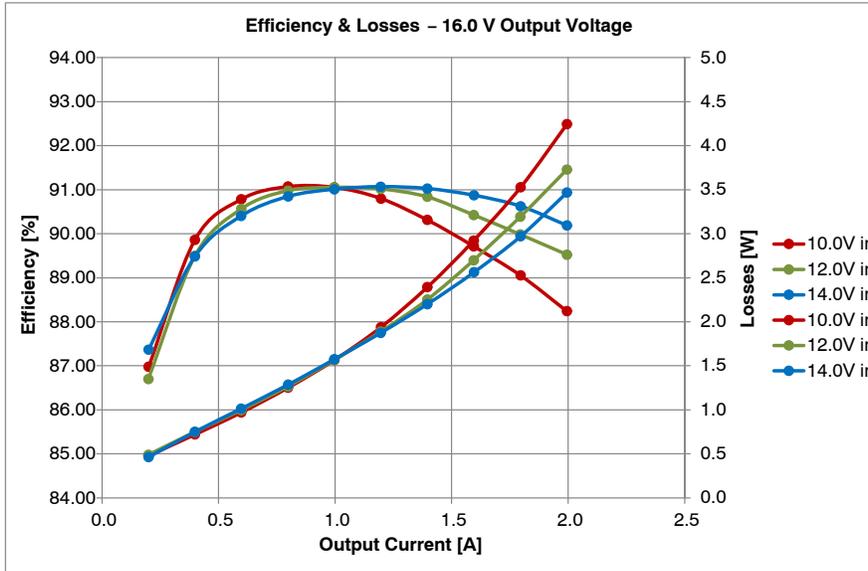


Figure 7. Efficiency

Thermal Image

The thermal image shows the circuit at an ambient temperature of 22 °C with an input voltage of 14.0 V.

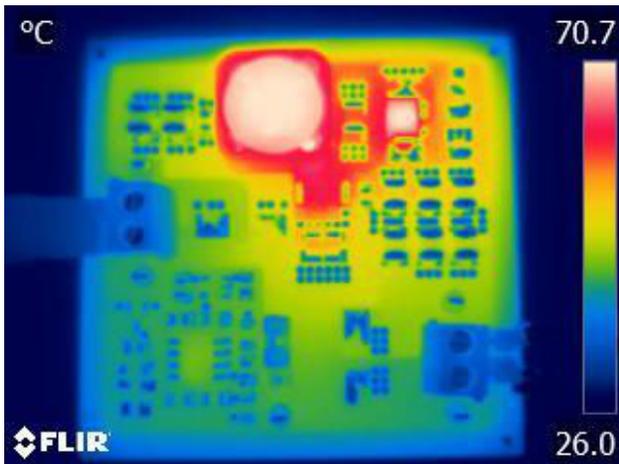


Figure 8. Thermal Image at 1.5 A Load

Table 2. COMPONENT TEMPERATURES

Component	Temperature
Inductor L1	71.7 °C
MOSFET Q1	64.0 °C
Diode D1	71.3 °C

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Transient Response

The response to a load step from 0.75 A to 1.5 A and vice versa at 14.0 V input voltage is shown in Figure 9.

Channel 1 Output current, load step from 0.75 A to 1.5 A and vice versa
500 mA/div, 2 ms/div

Channel 3

Output voltage, -163 mV (-1.0 %) undershoot, +163 mV (+1.0 %) overshoot
100 mV/div, 2 ms/div, AC coupled

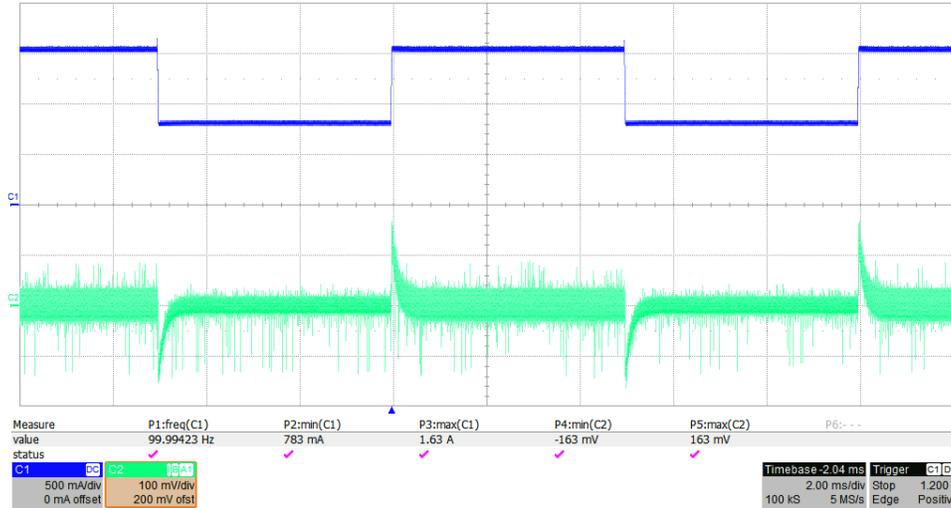


Figure 9. Transient Response for a 0.75 A Load Step

Frequency Response

The frequency response at 14.0 V input voltage and 1.5 A load is shown in Figure 10.

Trace 1
Trace 2

19.2 kHz bandwidth, -9 dB gain margin
58 ° phase margin

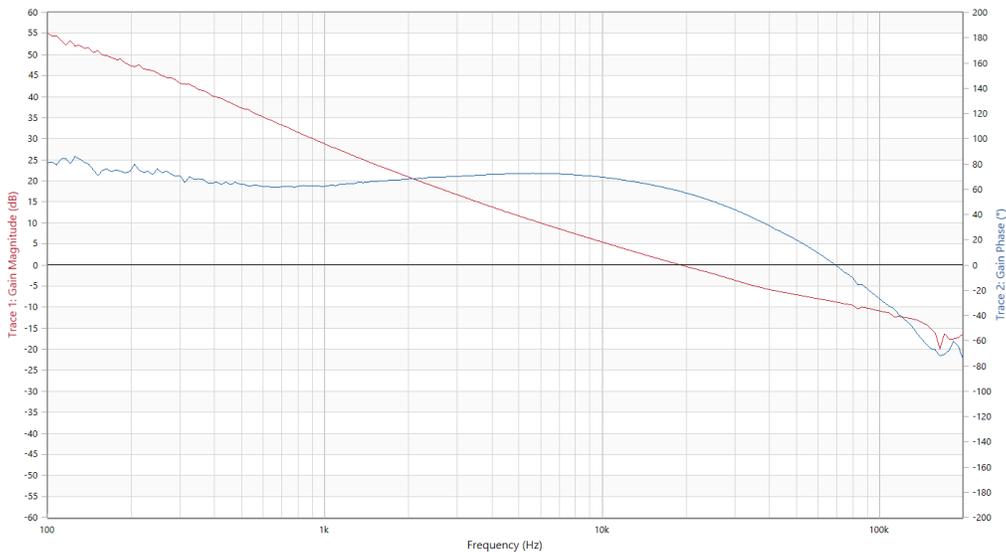


Figure 10. Frequency Response at 1.5 A Load

Table 3. BANDWIDTH AND STABILITY

Input Voltage	Load	Bandwidth	Phase Margin	Gain Margin
12.0 V	16.0 V @ 1.5 A	17.6 kHz	57 °	-8 dB
14.0 V	16.0 V @ 1.5 A	19.2 kHz	58 °	-9 dB
16.0 V	16.0 V @ 1.5 A	20.5 kHz	59 °	-9 dB

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Input Ripple

The input ripple voltage at 14.0 V input voltage and 1.5 A load is shown in Figure 11.

Channel 3

Input voltage, -59 mV (-0.4%) / $+61\text{ mV}$ ($+0.4\%$) Ripple
20 mV/div, 1 μs /div, AC coupled

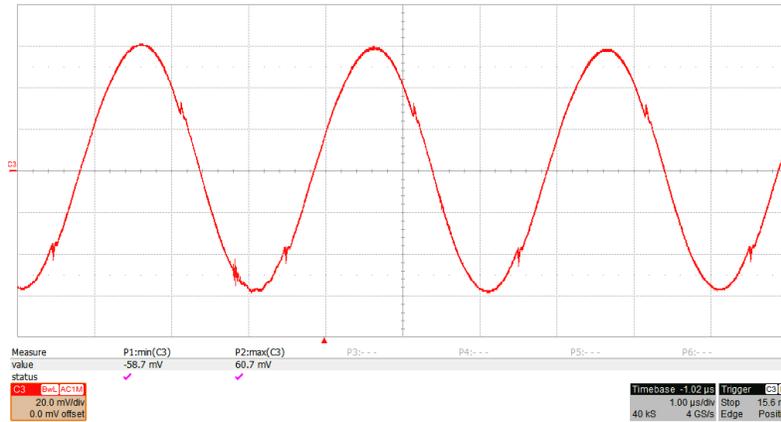


Figure 11. Input Ripple at 1.5 A Load

Output Ripple

The output ripple voltage at 14.0 V input voltage and 1.5 A load is shown in Figure 12.

Channel 3

Output voltage, -37 mV (-0.2%) / $+35\text{ mV}$ ($+0.2\%$) Ripple
20 mV/div, 1 μs /div, AC coupled

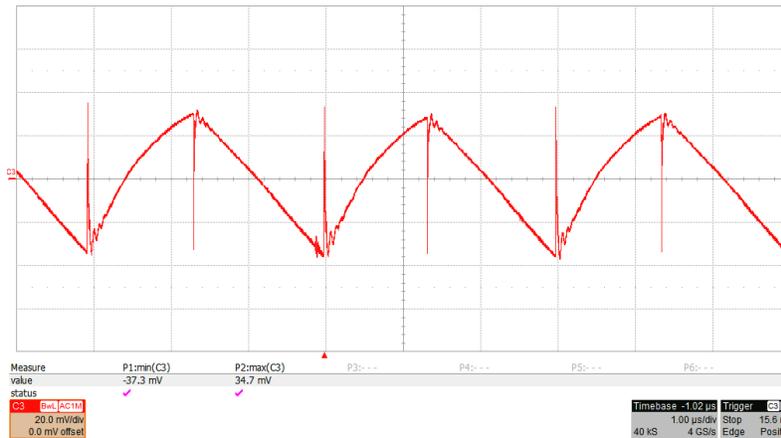


Figure 12. Output Ripple at 1.5 A Load

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Table 4. BILL OF MATERIALS

Designator	Quantity	Value	Part Number	Manufacturer	Description	Package
C1, C2, C3, C4, C6, C7, C12, C13	8	10 μ F	GCM32EC71H106KA03K	MuRata	Cap, Cerm, 10 μ F, 50 V, 10%, X7S, 1210, AEC-Q200	1210
C8, C11, C16, C18, C20	5	100 nF	GCM21BR71H104KA37K	Murata	Cap, Cerm, 100 nF, 50 V, 10%, X7R, 0805, AEC-Q200	0805
C9	1	4.7 μ F	GCM32ER71H475KA55	MuRata	Cap, Cerm, 4.7 μ F, 50 V, 10%, X7R, 1210, AEC-Q200	1210
C15	1	0.033 μ F	GCM219R72A333KA37D	MuRata	Cap, Cerm, 0.033 μ F, 100 V, 10%, X7R, 0805, AEC-Q200	0805
C17	1	100 pF	GCM21A5C2E101JX01D	MuRata	Cap, Cerm, 100 pF, 100 V, 5%, C0G/NP0, 0805, AEC-Q200	0805
C19	1	33 pF	GCM21A5C2J330JX01D	MuRata	Cap, Cerm, 33 pF, 50 V, 5%, C0G/NP0, 0805, AEC-Q200	0805
C21	1	4.7 μ F	GCM21BR71C475KA73K	MuRata	Cap, Cerm, 4.7 μ F, 16 V, 10%, X7R, AEC-Q200	0805
D1	1	60 V	NRVBS360BNT3G	onsemi	Diode, Schottky, 60 V, 3 A, AEC-Q101	SMB
D2	1	70 V	SBAV70LT1G	onsemi	Diode, Switching, 70 V, 0.25 A, AEC-Q101	SOT-23
J1, J2	2	-	ED555/2DS	On-Shore Technology	Terminal Block, 3.5mm Pitch, 2x1, TH	7.0x8.2x6.5mm
L1	1	10 μ H	MSD1278H-103MED	Coilcraft	Coupled inductor, 10 μ H, 5.6 A, 0.036 ohm, AEC-Q200	12.3x12.3mm
P1	1	-	61300311121	Wurth Elektronik	THT Vertical Pin Header WR-PHD, Pitch 2.54 mm, Single Row, 3 pins	2.54x7.62mm
Q1	1	-	NVTF55C680NLWFTAG	onsemi	MOSFET, N-CH, 80 V, 22 A	u8FL
R2	1	0	CRCW08050000Z0EA	Vishay Dale	Resistor, 0 Ohm, 1%, AEC-Q200	0805
R3	1	100	CRCW0805100RFKEA	Vishay Dale	Resistor, 100 Ohm, 1 %, 1/8 W, AEC-Q200	0805
R4	1	100k	CRCW0805100KFKEA	Vishay Dale	Resistor, 100k, 1 %, 1/8 W, AEC-Q200	0805
R5	1	10	CRCW080510R0FKTA	Vishay Dale	Resistor, 10.0 Ohm, 1 %, 1/8 W, AEC-Q200	0805
R6	1	8.06k	CRCW08058K06FKEA	Vishay Dale	Resistor, 8.06k, 1 %, 1/8 W, AEC-Q200	0805
R7	1	0.025	ERJ-C1CFR025U	Panasonic	Resistor, 0.025, 1%, 2 W, AEC-Q200	1020
R8	1	3.32k	CRCW08053K32FKEA	Vishay-Dale	Resistor, 3.32k, 1 %, 1/8 W, AEC-Q200	0805
TP1, TP2	2	-	5000	Keystone	Test Point, Miniature, Red, TH	2.54x7.62mm
TP3, TP4	2	-	5001	Keystone	Test Point, Miniature, Black, TH	2.54x7.62mm
TP5	1	-	5002	Keystone	Test Point, Miniature, White, TH	2.54x7.62mm
U1	1	-	NCV887103D1R2G	onsemi	Non-Synchronous Boost Controller, 45 V, AEC-Q100	SOIC-8
U2	1	-	NCV4295CSN50T1G	onsemi	Off-Battery LDO, 5 V, 30 mA, AEC-Q100	TSOP-5

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