

ON Semiconductor

Is Now

onsemi™

To learn more about onsemi™, please visit our website at
www.onsemi.com

onsemi and **onsemi** and other names, marks, and brands are registered and/or common law trademarks of Semiconductor Components Industries, LLC dba "**onsemi**" or its affiliates and/or subsidiaries in the United States and/or other countries. **onsemi** owns the rights to a number of patents, trademarks, copyrights, trade secrets, and other intellectual property. A listing of **onsemi** product/patent coverage may be accessed at www.onsemi.com/site/pdf/Patent-Marking.pdf. **onsemi** reserves the right to make changes at any time to any products or information herein, without notice. The information herein is provided "as-is" and **onsemi** makes no warranty, representation or guarantee regarding the accuracy of the information, product features, availability, functionality, or suitability of its products for any particular purpose, nor does **onsemi** assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation special, consequential or incidental damages. Buyer is responsible for its products and applications using **onsemi** products, including compliance with all laws, regulations and safety requirements or standards, regardless of any support or applications information provided by **onsemi**. "Typical" parameters which may be provided in **onsemi** data sheets and/or specifications can and do vary in different applications and actual performance may vary over time. All operating parameters, including "Typicals" must be validated for each customer application by customer's technical experts. **onsemi** does not convey any license under any of its intellectual property rights nor the rights of others. **onsemi** products are not designed, intended, or authorized for use as a critical component in life support systems or any FDA Class 3 medical devices or medical devices with a same or similar classification in a foreign jurisdiction or any devices intended for implantation in the human body. Should Buyer purchase or use **onsemi** products for any such unintended or unauthorized application, Buyer shall indemnify and hold **onsemi** and its officers, employees, subsidiaries, affiliates, and distributors harmless against all claims, costs, damages, and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if such claim alleges that **onsemi** was negligent regarding the design or manufacture of the part. **onsemi** is an Equal Opportunity/Affirmative Action Employer. This literature is subject to all applicable copyright laws and is not for resale in any manner. Other names and brands may be claimed as the property of others.

Automotive 4-Switch Buck-Boost Pre-Regulator Reference Design

Overview

This automotive buck–boost pre–regulator reference design describes the operation and performance for a typical pre–regulator application needed in various automotive applications like ADAS, gateway and infotainment. It ensures proper supply of all subsequent loads and regulators to ensure uninterrupted operation, even at significant input voltage variation.

The design demonstrates the NCV81599 controller capabilities and incorporates four NVTFS5C460NL 40 V N–channel FETs for the power stage.

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, but it also provides access to key features of the NCV81599. These include wide input voltage range from 4.5 V to 32 V, dynamically programmed frequency from 150 kHz to 1.2 MHz, I²C interface, independent input and output current sensing, over–voltage and over–current protection as well as over–temperature protection.

Key Features

- Complete Automotive Reference Design
- Synchronous 4–switch Buck–boost Converter with an Input Voltage Range of nominal 6.0 to 18.0 V, withstands Peaks up to 35 V / 40 V (20 ns)
- 450 kHz Switching Frequency for High Efficiency
- ON Semiconductor NCV81599 4–switch Buck–boost Controller, NVTFS5C460NL 40 V N–channel FET, NRVBSS14HE 40 V Schottky diode, NCT375 Digital Temperature Sensor
- NCT375 Digital Temperature Sensor with I²C Interface for Temperature Monitoring
- Small Form Factor PCB with Four Layers, 51 x 51 mm, Single–sided Assembly



ON Semiconductor®

www.onsemi.com

REFERENCE DESIGN

Table 1. SPECIFICATIONS

Device	NCV81599
Application	Automotive 4–Switch Buck–Boost Pre–Regulator
Input Voltage	6 V to 18 V DC, 35 V / 40 V (20 ns) peak
Output Power	45 W
Topology	4–Switch Buck–Boost
Isolation	Non–Isolated
Output Voltage	9.0 V
Nominal Current	5.0 A



Figure 1. Reference Design Board Image

Schematics

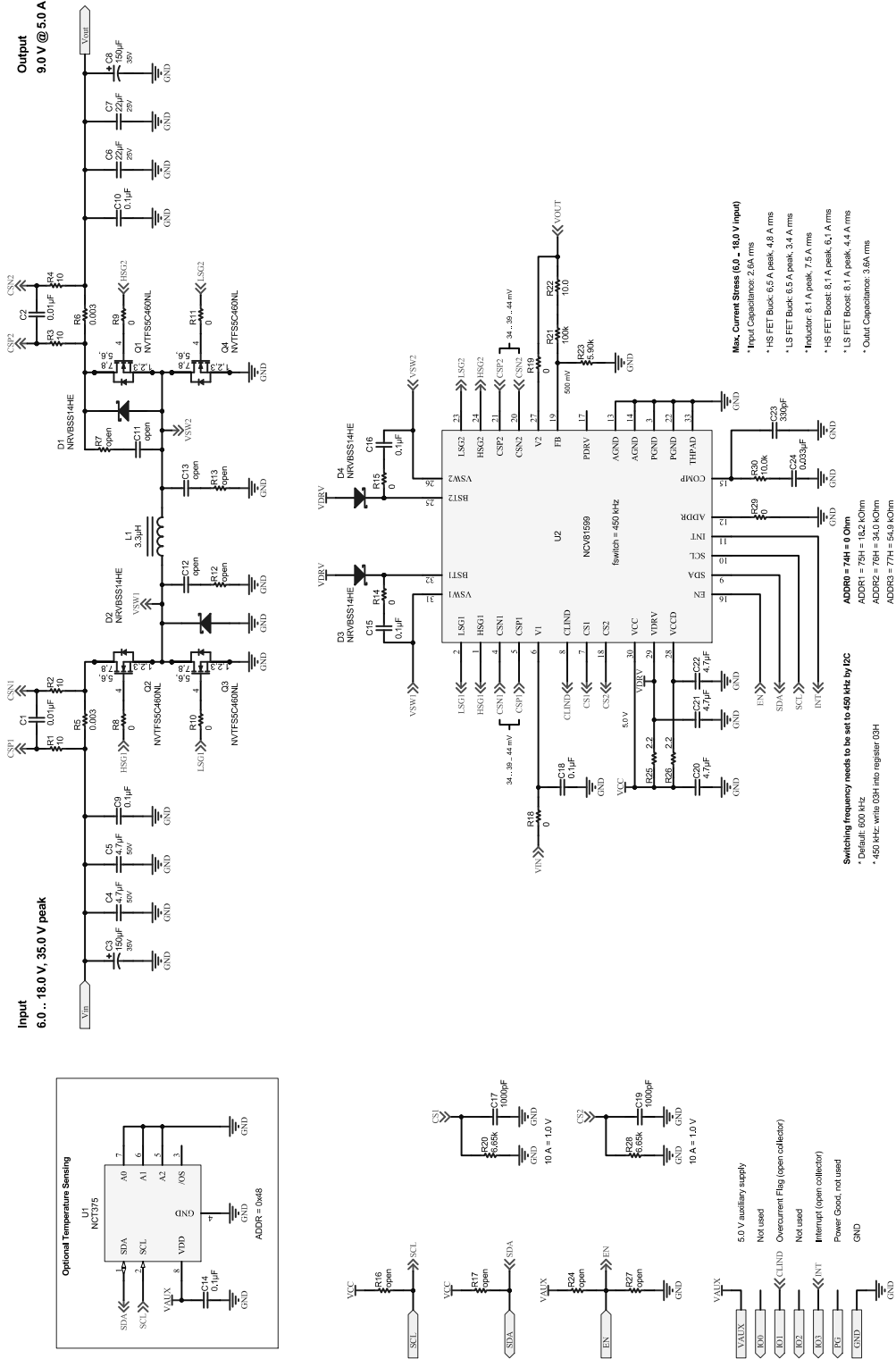


Figure 2. NCV81599 4-switch Buck-boost Schematic

TND6348/D

Board Layout

Figure 3, 4, shows the top and bottom assembly and the four layers of the PCB. The converter size is 51 mm x 51 mm

(length x width) where the height of the PCB is approximately 13 mm.

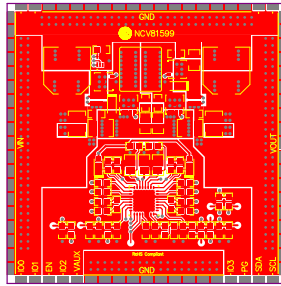


Figure 3. Top Layer and Assembly Drawing

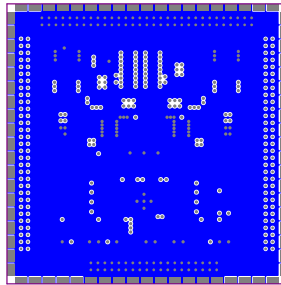


Figure 4. Bottom Layer and Assembly Drawing

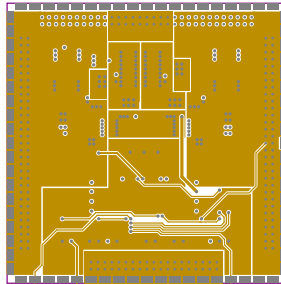


Figure 5. Inner 1 Layer

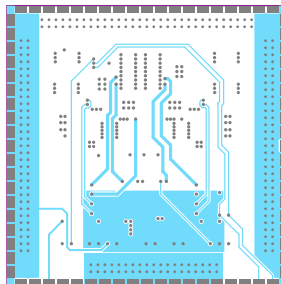


Figure 6. Inner 2 Layer

PERFORMANCE SUMMARY

Efficiency

The efficiency for 6.0, 12.0 and 18.0 V input voltage is shown in Figure 7.

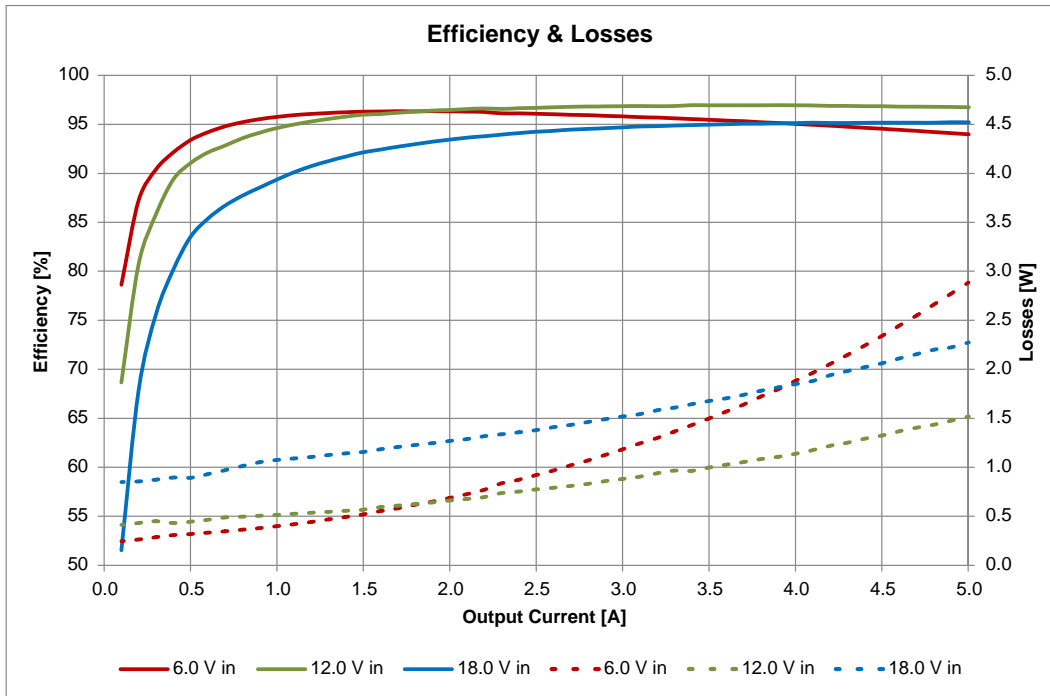


Figure 7. Efficiency for 6.0, 12.0, 18.0 V Input Voltage

Transient Response

The response to a load step from 2.5 A to 5.0 A and vice versa at 12.0 V input voltage is shown in Figure 8.

- Output voltage, -300 mV /+3.3 % undershoot, +296 mV / +3.3 % overshoot
- 100 mV/div, 2 ms/div, AC coupled

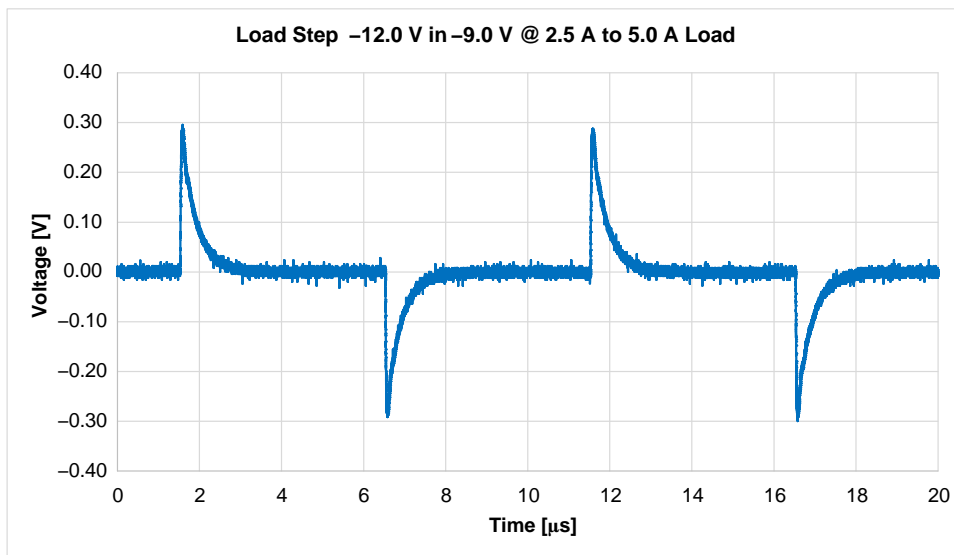


Figure 8. Transient Response on 2.5 A Load Step

TND6348/D

Frequency Response

The frequency response at 12.0 V input voltage and 5.0 A load is shown in Figure 9.

- 6.1 kHz bandwidth
- 82° phase margin
- -27 dB gain margin

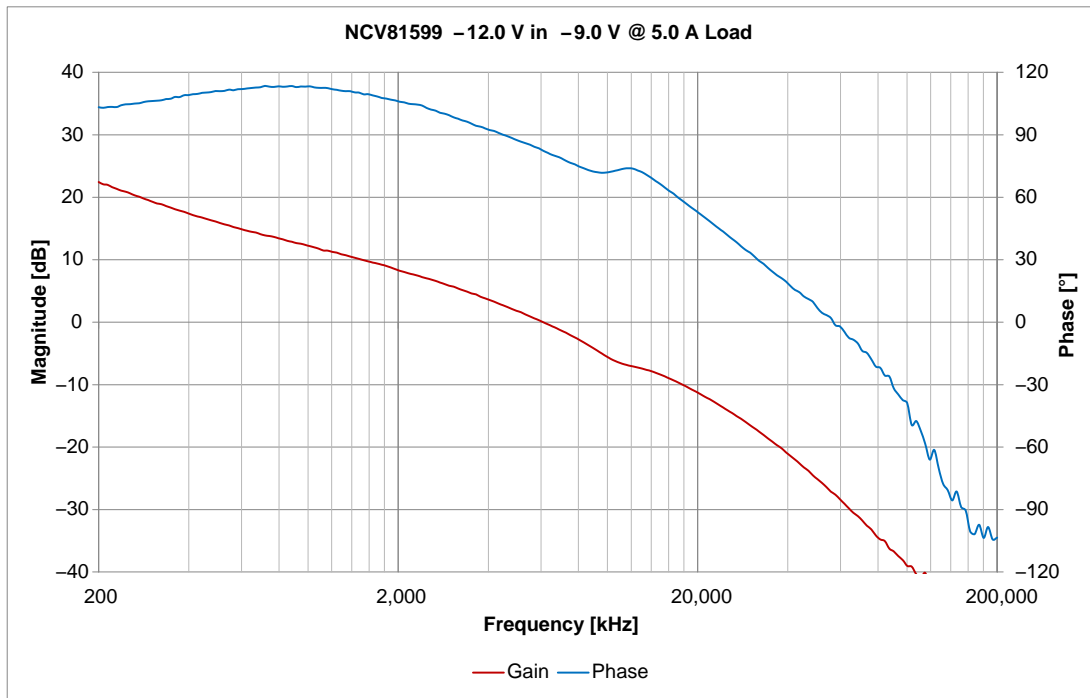


Figure 9. Frequency Response at 5.0 A Load

Table 2.

Input Voltage	Load	Bandwidth	Phase Margin	Gain Margin
6.0 V	12.0 V @ 5.0 A	2.6 kHz	81°	-18 dB
9.0 V	12.0 V @ 5.0 A	4.9 kHz	83°	-21 dB
12.0 V	12.0 V @ 5.0 A	6.1 kHz	82°	-27 dB
16.0 V	12.0 V @ 5.0 A	6.5 kHz	83°	-28 dB

TND6348/D

Input Ripple

The input ripple voltage at 16.0 V input voltage and 5.0 A load is show in Figure 10.

- -116 mV / -0.7 % undershoot, +108 mV / +0.7 % overshoot
- 50 mV/div, 1 μ s/div, AC coupled

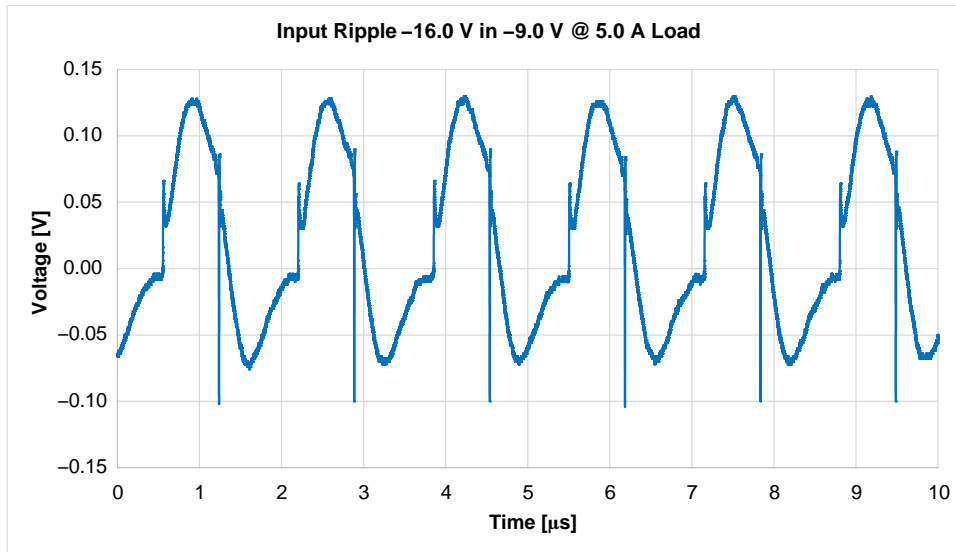


Figure 10. Input Ripple at 5.0 A Load

Output Ripple

The output ripple voltage at 6.0 V input voltage and 5.0 A load is show in Figure 11.

- -60 mV / -0.7 % undershoot, +50 mV / +0.6 % overshoot
- -178 mV / -2.0 % and 148 mV / 1.6 % spikes
- 50 mV/div, 1 μ s/div, AC coupled

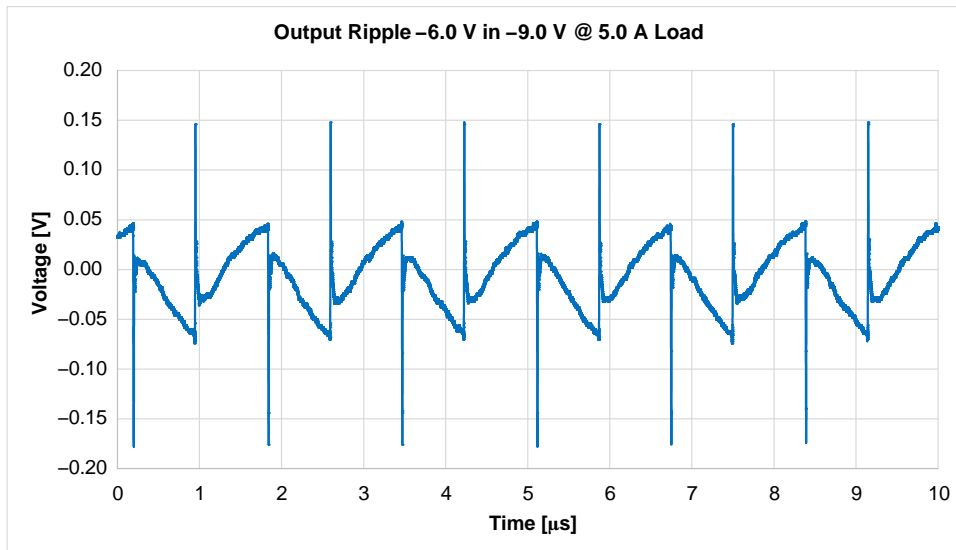



Figure 11. Output Ripple at 5.0 A Load

TND6348/D

Table 3. BILL OF MATERIALS (BOM)

Designator	Qty	Value	Part Number	Manufacturer	Description	Package
C1, C2	2	0.01uF	GCJ188R71H103KA01	MuRata	CAP, CERM, 0.01 μ F, 50 V, \pm 10%, X7R, 0603, AEC-Q200	0603
C3, C8	2	150uF	GYA1V151MCQ1GS	Nichicon	CAP, Hybrid Polymer, 150 μ F, 35 V, \pm 20%, AEC-Q200	D8 x L10 mm
C4, C5	2	4.7uF	GCJ32ER71H475KA12	MuRata	CAP, CERM, 4.7 μ F, 50 V, \pm 10%, X7S, 1210, AEC-Q200	1210
C6, C7	2	22uF	GCJ32EC71E226KE02	MuRata	CAP, CERM, 22 μ F, 25 V, \pm 10%, X7S, 1210, AEC-Q200	1210
C9, C10, C14, C15, C16, C18	9	0.1uF	GCJ188R71H104KA12	MuRata	CAP, CERM, 0.1 μ F, 50 V, \pm 10%, X7R, 0603, AEC-Q200	0603
C17, C19	2	1000pF	GCJ188R71H102KA01	MuRata	CAP, CERM, 1000 pF, 50 V, \pm 10%, X7R, 0603, AEC-Q200	0603
C20, C21, C22	3	4.7uF	GCJ21BR71C475KA01	MuRata	CAP, CERM, 4.7 μ F, 16 V, \pm 10%, X7R, 0805, AEC-Q200	0805
C23	1	330pF	GCM1885C2A331JA16	MuRata	CAP, CERM, 330 pF, 10 V, \pm 5%, C0G, 0603, AEC-Q200	0603
C24	1	0.033uF	GCJ188R71H333KA12	MuRata	CAP, CERM, 0.033 μ F, 50 V, \pm 10%, X7R, 0603, AEC-Q200	0603
D1, D2, D3, D4	4	40V	NRVBS514HE	ON Semiconductor	Diode, Schottky, 40 V, 1 A, SOD-323HE	SOD-323HE
L1	1	3.3uH	XAL7070-332MEB	Coilcraft	Inductor, Shielded, Composite, 3.3 μ H, 15.1 A, 0.01 Ω , SMD	7.2 x 7.0 x 7.5 mm
Q1, Q2, Q3, Q4	4	40V	NVTF55C460NLWFTAG	ON Semiconductor	MOSFET, N-CH, 40 V, 74 A, AEC-Q101, 8-PowerWDFN	8-PowerWDFN
R1, R2, R3, R4	4	10	CRCW060310R0JNEA	Vishay-Dale	RES, 10, 5%, 0.1 W, 0603	0603
R5, R6	2	0.003	KRL2012E-M-R003-F-T5	Susumu Co Ltd	RES, 0.003, 1%, 1 W, 0805 Wide, AEC-Q200	0805 Wide
R8, R9, R10, R11, R14, R15, R18, R19, R29	9	0	CRCW06030000Z0EA	Vishay-Dale	RES, 0, 5%, 0.1 W, 0603	0603
R16, R17, R24, R27	4	10k	CRCW060310K0JNEA	Vishay-Dale	RES, 10 k, 5%, 0.1 W, 0603	0603
R20, R28	2	6.65k	CRCW06036K65FKEA	Vishay-Dale	RES, 6.65 k, 1%, 0.1 W, 0603	0603
R21	1	100k	CRCW0603100KFKEA	Vishay-Dale	RES, 100 k, 1%, 0.1 W, 0603	0603
R22	1	10.0	CRCW060310R0FKEA	Vishay-Dale	RES, 10.0, 1%, 0.1 W, 0603	0603
R23	1	5.90k	CRCW06035K90FKEA	Vishay-Dale	RES, 5.90 k, 1%, 0.1 W, 0603	0603
R25, R26	2	2.2	CRCW06032R20JNEA	Vishay-Dale	RES, 2.2, 5%, 0.1 W, 0603	0603
R30	1	10.0k	CRCW060310K0FKEA	Vishay-Dale	RES, 10.0 k, 1%, 0.1 W, 0603	0603
U1	1		NCT375MNR2G	ON Semiconductor	Digital Temperature Sensor with 2-Wire Interface	DFN-8
U2	1		NCV81599	ON Semiconductor	Automotive Grade USB Power Delivery 4-Switch Buck Boost Controller	QFNW32

ON Semiconductor and  are trademarks of Semiconductor Components Industries, LLC dba ON Semiconductor or its subsidiaries in the United States and/or other countries. ON Semiconductor owns the rights to a number of patents, trademarks, copyrights, trade secrets, and other intellectual property. A listing of ON Semiconductor's product/patent coverage may be accessed at www.onsemi.com/site/pdf/Patent-Marking.pdf. ON Semiconductor reserves the right to make changes without further notice to any products herein. ON Semiconductor makes no warranty, representation or guarantee regarding the suitability of its products for any particular purpose, nor does ON Semiconductor assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation special, consequential or incidental damages. Buyer is responsible for its products and applications using ON Semiconductor products, including compliance with all laws, regulations and safety requirements or standards, regardless of any support or applications information provided by ON Semiconductor. "Typical" parameters which may be provided in ON Semiconductor data sheets and/or specifications can and do vary in different applications and actual performance may vary over time. All operating parameters, including "Typicals" must be validated for each customer application by customer's technical experts. ON Semiconductor does not convey any license under its patent rights nor the rights of others. ON Semiconductor products are not designed, intended, or authorized for use as a critical component in life support systems or any FDA Class 3 medical devices or medical devices with a same or similar classification in a foreign jurisdiction or any devices intended for implantation in the human body. Should Buyer purchase or use ON Semiconductor products for any such unintended or unauthorized application, Buyer shall indemnify and hold ON Semiconductor and its officers, employees, subsidiaries, affiliates, and distributors harmless against all claims, costs, damages, and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if such claim alleges that ON Semiconductor was negligent regarding the design or manufacture of the part. ON Semiconductor is an Equal Opportunity/Affirmative Action Employer. This literature is subject to all applicable copyright laws and is not for resale in any manner.

PUBLICATION ORDERING INFORMATION

LITERATURE FULFILLMENT:

Email Requests to: orderlit@onsemi.com

ON Semiconductor Website: www.onsemi.com

TECHNICAL SUPPORT

North American Technical Support:
Voice Mail: 1 800-282-9855 Toll Free USA/Canada
Phone: 011 421 33 790 2910

Europe, Middle East and Africa Technical Support:
Phone: 00421 33 790 2910

For additional information, please contact your local Sales Representative