A 12-V/1-A Secondary Side Regulated Isolated Flyback Converter for Automotive Applications

NCV12711SSRGEVB

SPECIFICATION

Devices	Applications	Input Voltage	Output Power	Topology	Board Size
NCV12711	Automotive	4 – 45 V dc	12 W	Current−Mode Flyback	100 x 47 x 15 mm
Output Spec.	**Turn on Time**	**Efficiency**	**Operating Temperature**	**Cooling**	**Standby Power**
12 V/1 A	< 100 ms	Peaks to 89 % @ full load	0 – 50°C	Open Frame in Still Air	See the tables on page 8

DESCRIPTION

This evaluation board user’s manual provides elementary information about a secondary side regulated flyback converter NCV12711SSRGEVB built with the NCV12711 operated in current−mode control at 100 kHz. This control circuit offers many features to build an energy−efficient converter with all the needed protections like cycle−by−cycle current limit with a 250−mV sense voltage, over−current protection (OCP) and over−voltage protection (OVP) on the VCC pin. The controller drives an N−channel MOSFET as with any classical flyback converter at a user−adjustable switching frequency. The secondary side hosts a low−V_f diode for efficient rectification in continuous conduction mode (CCM).

The primary−side section drives a transformer whose primary inductance is 8 μH. The current is sensed via two paralleled 40−mΩ resistors which limit the maximum output current to a safe value in fault condition. The board is rated to 12 W of continuous output power in free air at the lowest input voltage. This level is delivered down to a 4.5−V input. The converter is able to deliver output power up to 4−V input, which is the turn−off level adjusted by an UVLO resistor divider. At higher input voltages, the board may deliver more power but thermal runaway may happen and the board temperature must be monitored.

The regulation is ensured directly on secondary side requiring the use of an optocoupler. The advantage of this solution is better output voltage regulation in comparison with Primary−Side−Regulated converter.

The switch SW1 let you select different configurations to test the circuit:

1. *a* is closed, *b* open: in this mode, the VCC and VIN pin are connected together while the auxiliary winding is not used. The maximum input voltage is 25 V; going beyond this value will trip the OVP on VCC pin.
2. *b* is closed, *a* open: in this mode, the controller is supplied by the VIN pin only during start−up sequence and V_{CC} is biased by the rectified auxiliary supply. The input voltage can go up to 45 V.
3. *a* and *b* are open: the controller is self−supplied via internal LDO and the auxiliary winding is not used. The input voltage can go up to 45 V.

Due to secondary side regulation, the switch SW1 affects only the efficiency of the system. For more details, see the Efficiency and Standby data in TEST DATA section.

The internal operational amplifier coupled to external components ensures the realization of a type 2 compensator. Using the simulation model or a bench measurement, components values were adjusted to crossover above 1 kHz. The maximum crossover is limited by the right−half−plane−zero (RHPZ) which degrades the phase response at the lowest input voltage and the largest output current. The board is equipped with two connectors letting you easily connect the network analyzers probes for a convenient measurement. The collected graphs show a comfortable phase margin at crossover.

A simple front−end filter limits the amount of parasitic noise going back to the source and it must be properly damped to avoid interaction with the downstream converter. C_9 is providing that function with its equivalent series resistance (ESR).

KEY FEATURES OF NCV12711

- Internal 20–mA current source for lossless start–up sequence and self–supply operation
- Smooth start–up sequence with frequency sweep
- Internal operational amplifier with precise 2.5–V reference voltage
- Current–mode control operation
- Short circuit protection
- Over voltage protection
- Input Voltage UVLO with Hysteresis
- Shutdown threshold for external disable
- 0% duty ratio mode for low standby power
- Single Resistor Programmable Oscillator
- User–Adjustable Soft–Start Ramp

BOARD PICTURES

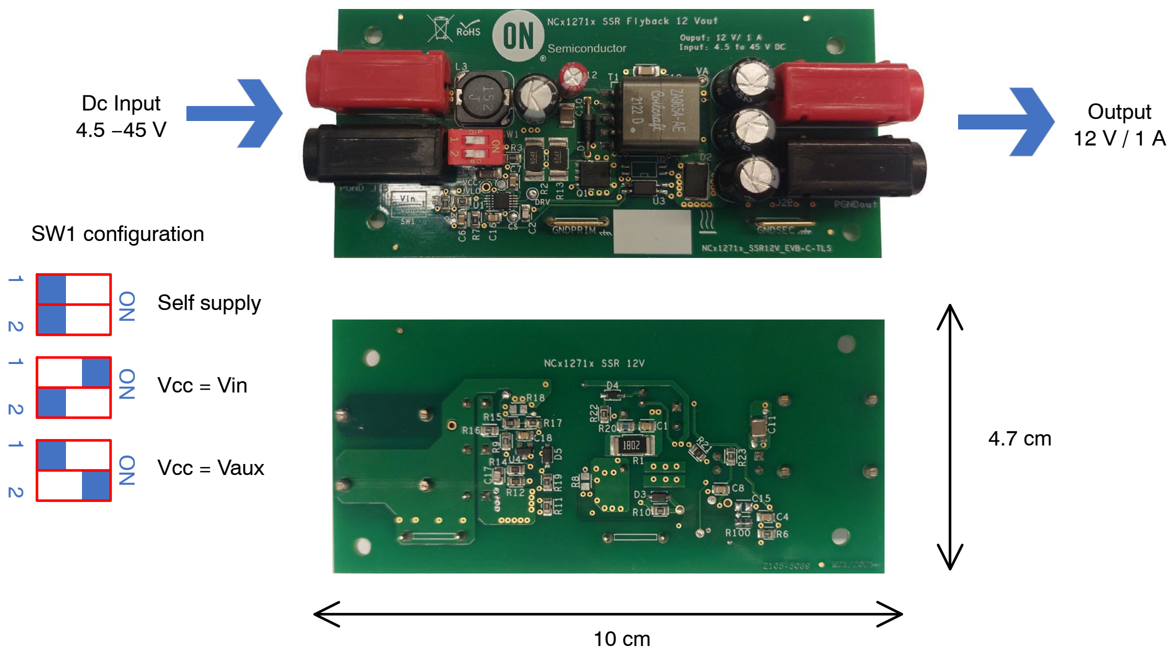

Figure 1. Top/Bottom Photo of the NCV12711SSRGEVB Evaluation Board

EVALUATION BOARD SCHEMATIC DIAGRAM

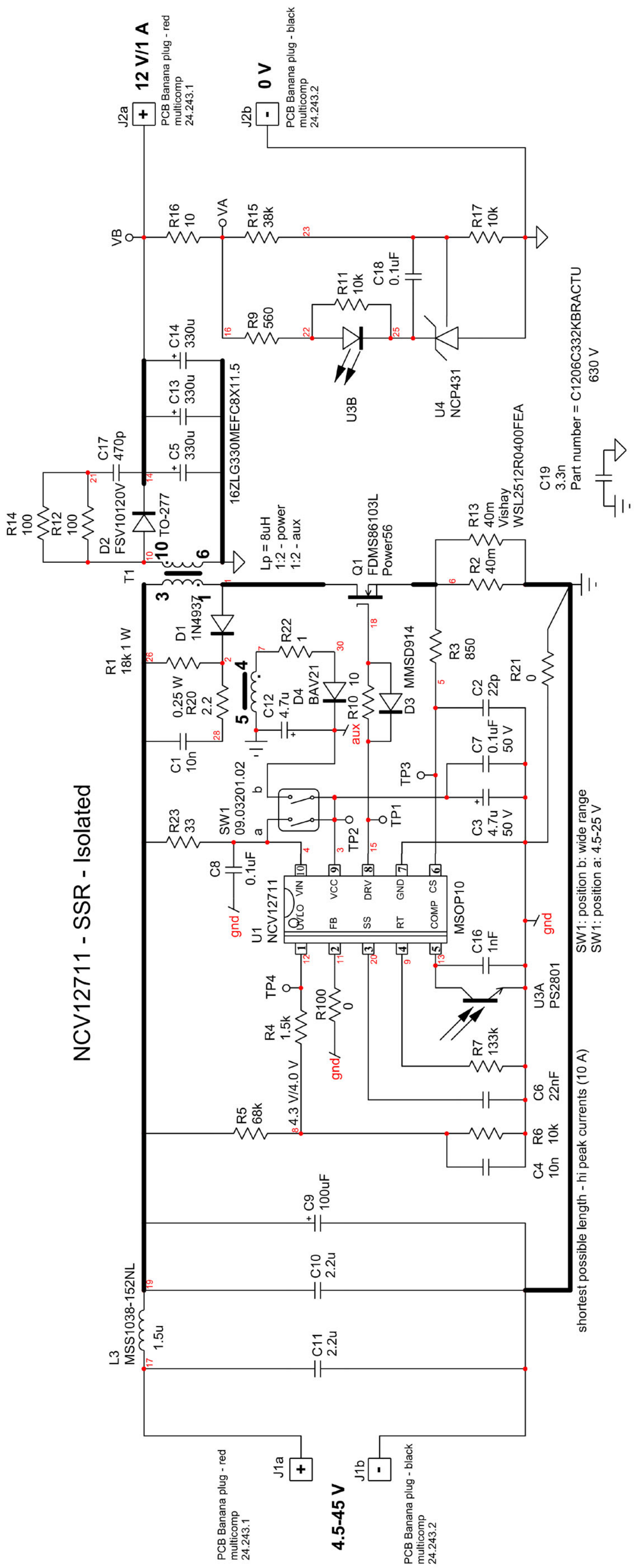

Figure 2. Schematic of the NCV12711SSRGEVB Evaluation Board

MAGNETICS DATA

ZA9654−AE from Coilcraft:

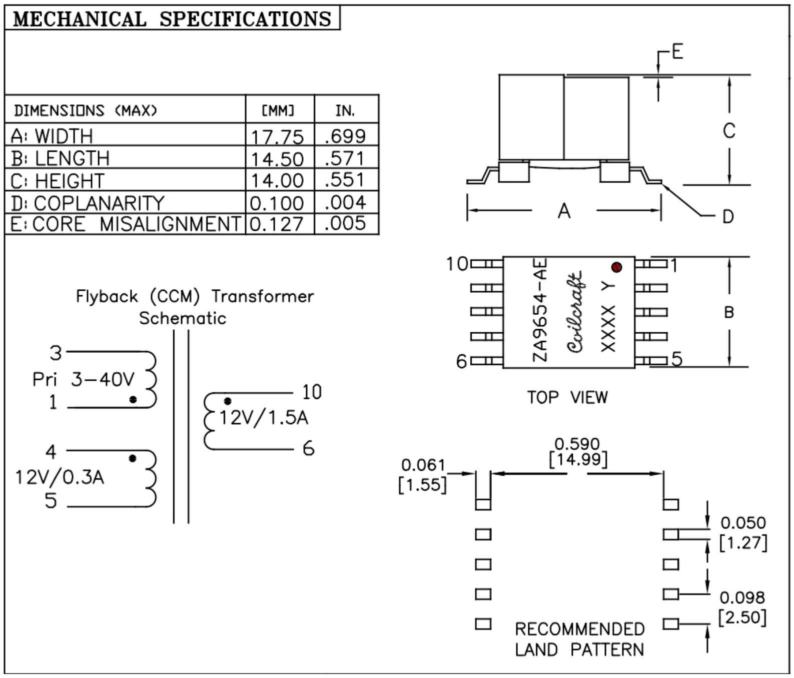

Figure 3. Mechanical Specifications

ELECTRICAL SPECIFICATIONS "ALL ELECTRICAL SPECIFICATIONS @ 25°C"

INDUCTANCE(uH) (CSC) 100%
300KHZ, 0.1 VRMS, 0/11ADC

PINS	MIN	MAX
1−3(0A)	7.6	8.4
1−3(11A)	7.0	

DC RESISTANCE (OHMS) A/R

PINS		MAX
1−3		.044
10−6		.265
4−5		.550

HI POT(1mA) 100%
(VRMS, Applied for 1 minute)

VOLTAGE:	FROM PINS	TO PINS
1500	3,4	6
750	ALL PINS	CORE
500	1	4

LEAKAGE INDCTANCE(uH) A/R
300KHZ, 0.1 VRMS, 0 ADC

PINS	SHORT PINS	MAX
1−3	10−6	0.110
4−5	10−6	0.430

TRL 100%
Apply 0.05 Vrms, 30 KHZ to pins 1−3

MEASURE PINS:	MIN	MAX
10−6	1.940	2.060
4−5	1.940	2.060

Figure 4. Electrical Specifications

TEST DATA

Startup Time

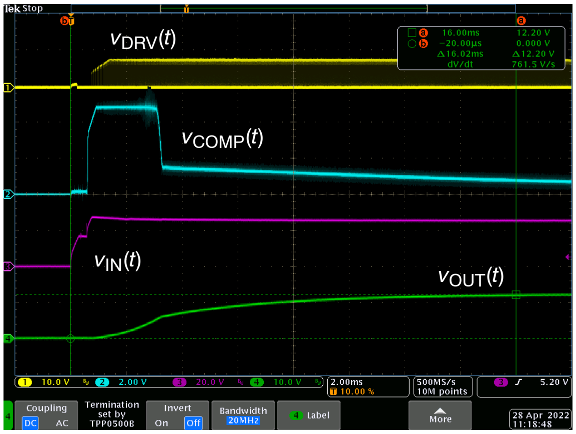

Figure 5. Self−supplied, V_{IN} = 25 V, I_{OUT} = 0 A, $t_{startup}$ = 16 ms

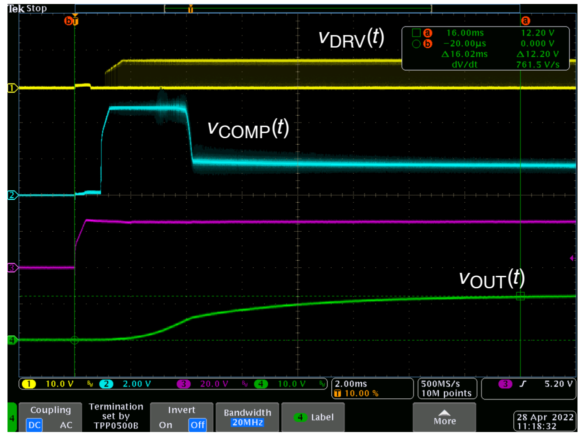

Figure 6. Self−supplied, V_{IN} = 25 V, I_{OUT} = 1 A, $t_{startup}$ = 16 ms

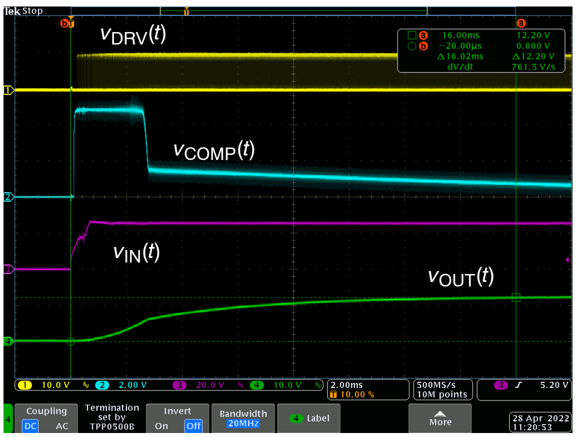

Figure 7. VCC = VIN, V_{IN} = 25 V, I_{OUT} = 0 A, $t_{startup}$ = 16 ms

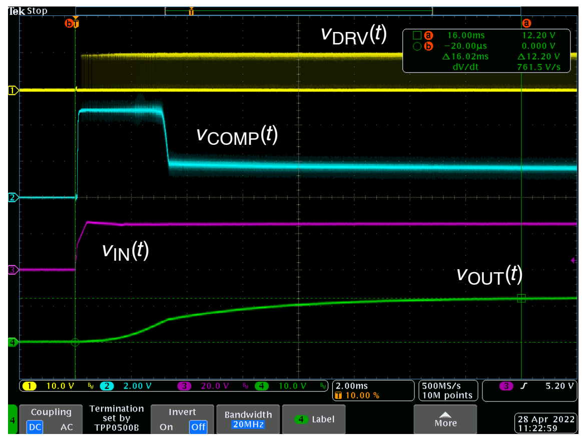

Figure 8. VCC = VIN, V_{IN} = 25 V, I_{OUT} = 1 A, $t_{startup}$ = 16 ms

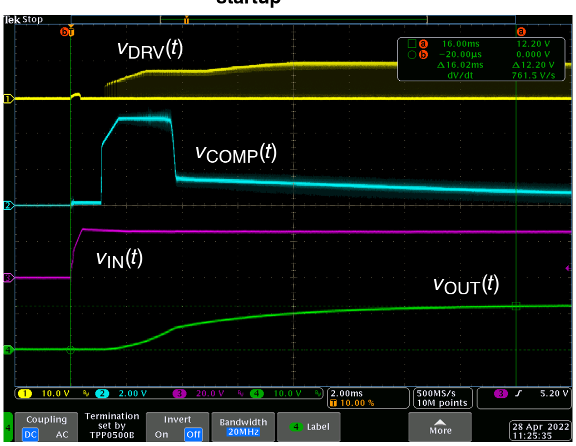

Figure 9. VCC = Vaux, V_{IN} = 25 V, I_{OUT} = 0 A, $t_{startup}$ = 16 ms

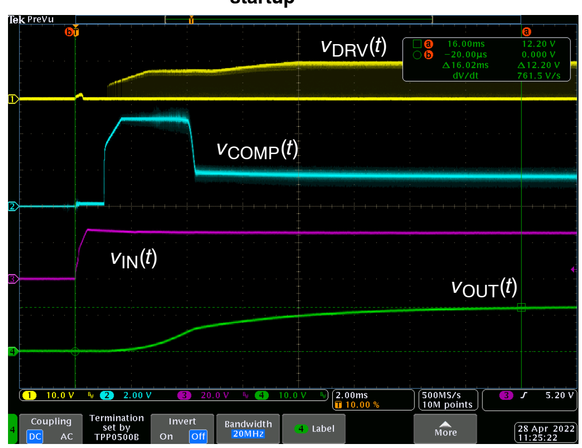

Figure 10. VCC = Vaux, V_{IN} = 25 V, I_{OUT} = 1 A, $t_{startup}$ = 16 ms

Steady−state Operation

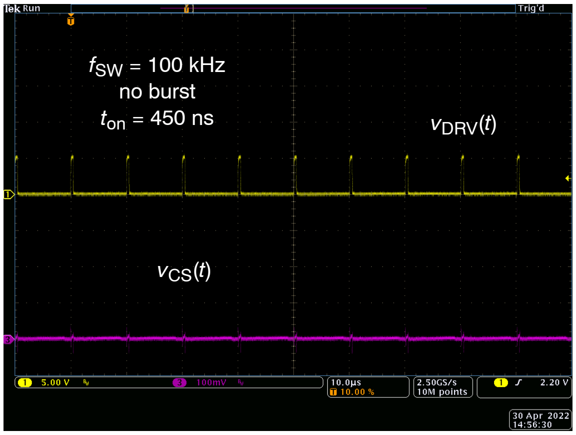

Figure 11. V_{IN} = 5.5 V, I_{OUT} = 0 A

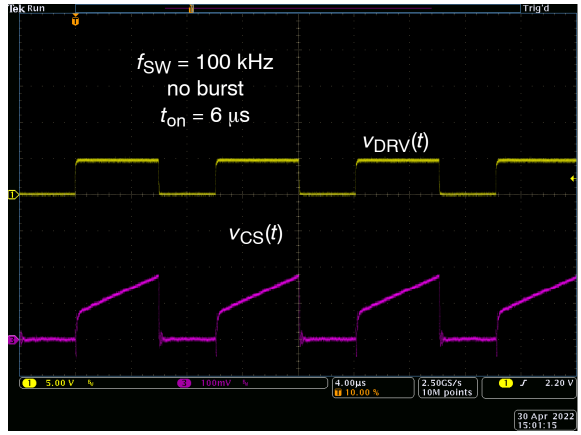

Figure 12. V_{IN} = 5.5 V, I_{OUT} = 1 A

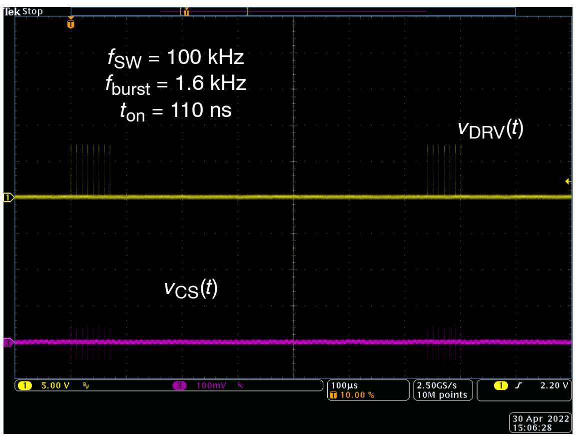

Figure 13. V_{IN} = 25 V, I_{OUT} = 0 A

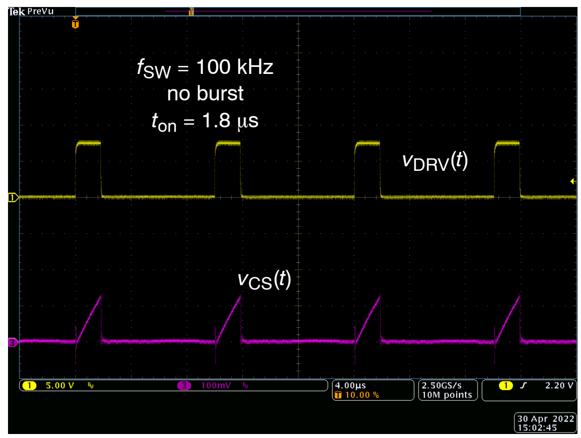

Figure 14. V_{IN} = 25 V, I_{OUT} = 1 A

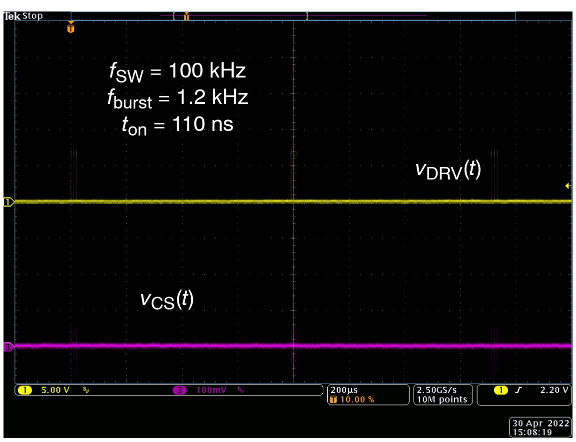

Figure 15. V_{IN} = 45 V, I_{OUT} = 0 A

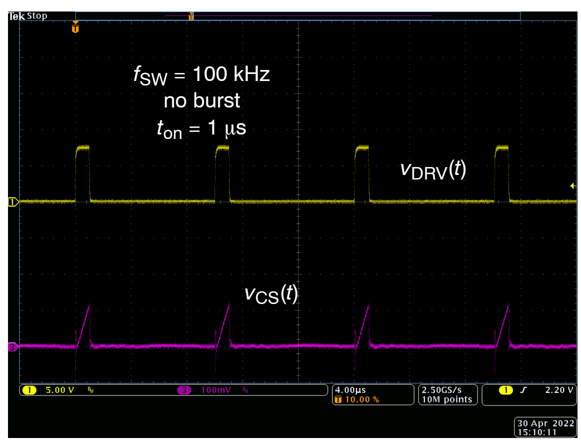

Figure 16. V_{IN} = 45 V, I_{OUT} = 1 A

Load Transient Response

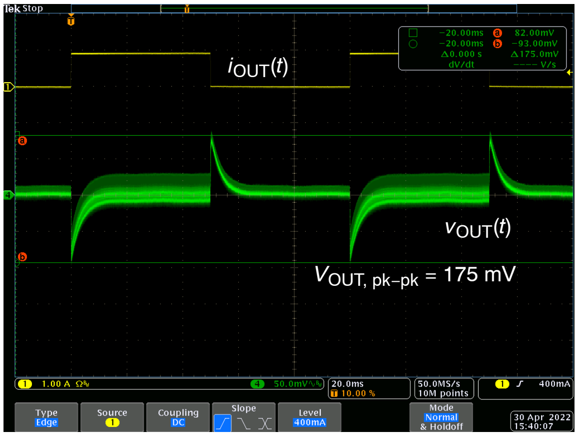

Figure 17. V_{IN} = 25 V, I_{OUT} = from 0.1 A to 1 A, Slew Rate 0.5 A/μs

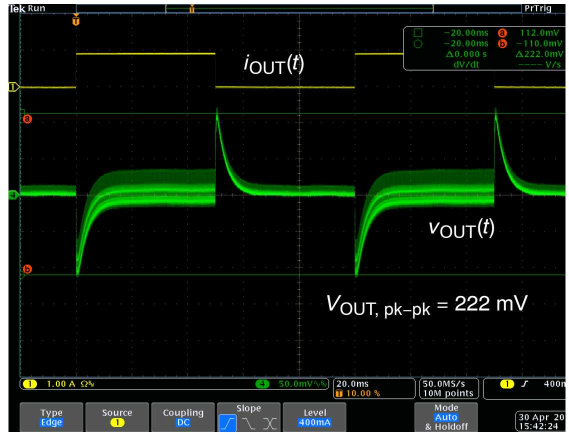

Figure 18. V_{IN} = 5.5 V, I_{OUT} = from 0.1 A to 1 A, Slew Rate 0.5 A/μs

Output Voltage Ripple

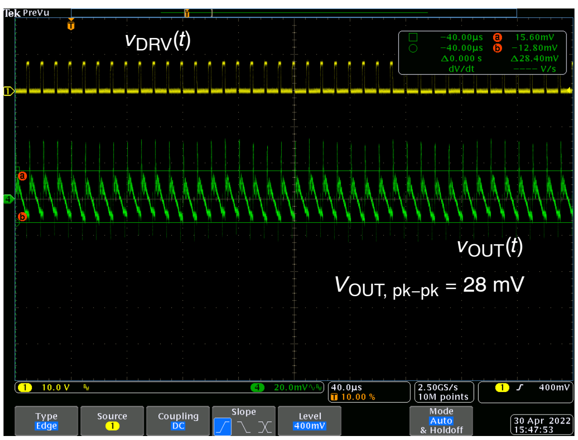

Figure 19. V_{IN} = 25 V, I_{OUT} = 1 A

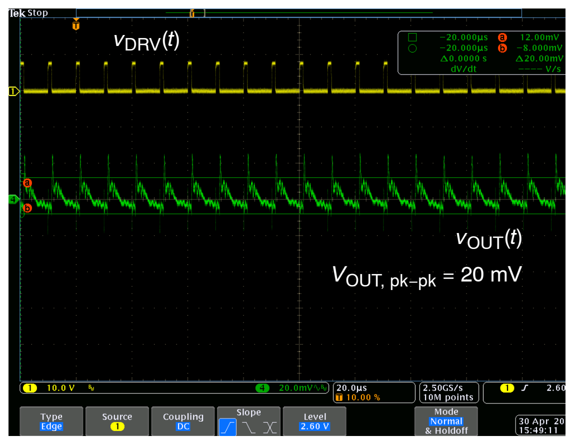

Figure 20. V_{IN} = 25 V, I_{OUT} = 0.5 A

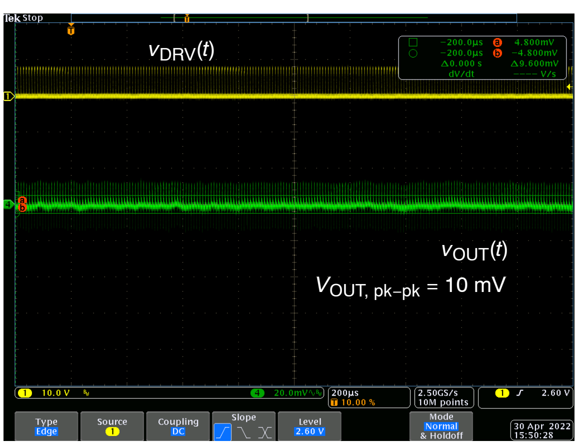

Figure 21. V_{IN} = 25 V, I_{OUT} = 0.1 A

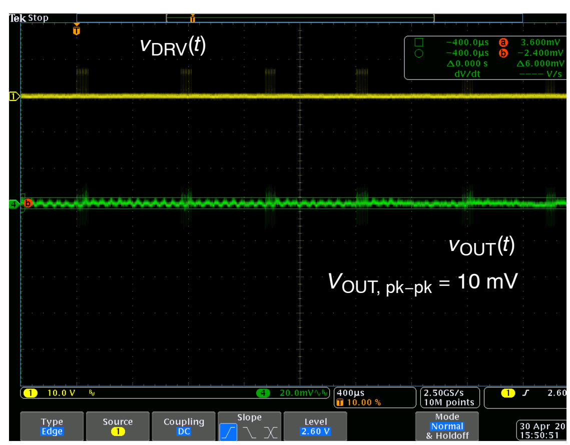

Figure 22. V_{IN} = 25 V, I_{OUT} = 0.0 A

Drain−Source Voltage

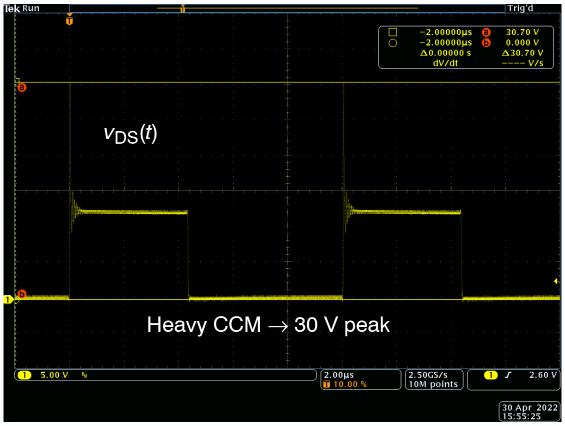

Figure 23. V_{IN} = 5.5 V, I_{OUT} = 1 A

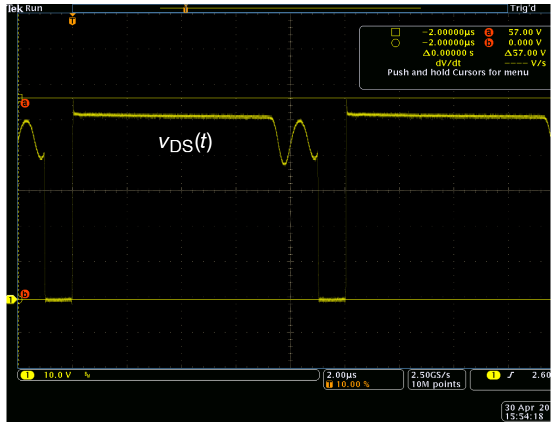

Figure 24. V_{IN} = 45 V, I_{OUT} = 1 A

Standby Data

Table 1. NO−LOAD INPUT POWER WHEN THE IC IS SELF−SUPLIED VIA LDO

V_{IN} (V)	I_{IN} (mA)	P_{IN} (mW)	V_{OUT} (V)
4.5	10.9	49.0	12.1
15	6.0	89.5	12.1
25	4.2	106.0	12.1
45	3.6	164.3	12.1

Table 2. NO−LOAD INPUT POWER WHEN THE VCC PIN IS CONNECTED TO VIN PIN

V_{IN} (V)	I_{IN} (mA)	P_{IN} (mW)	V_{OUT} (V)
4.5	11.2	50.6	12.1
15	6.0	90.0	12.1
25	4.3	106.5	12.1

Table 3. NO−LOAD INPUT POWER WHEN THE VCC PIN IS CONNECTED TO AUX WINDING

V_{IN} (V)	I_{IN} (mA)	P_{IN} (mW)	V_{OUT} (V)
4.5	24.7	111.3	12.1
15	10.5	156.5	12.1
25	5.0	125.5	12.1
45	2.8	125.1	12.1

Efficiency Data

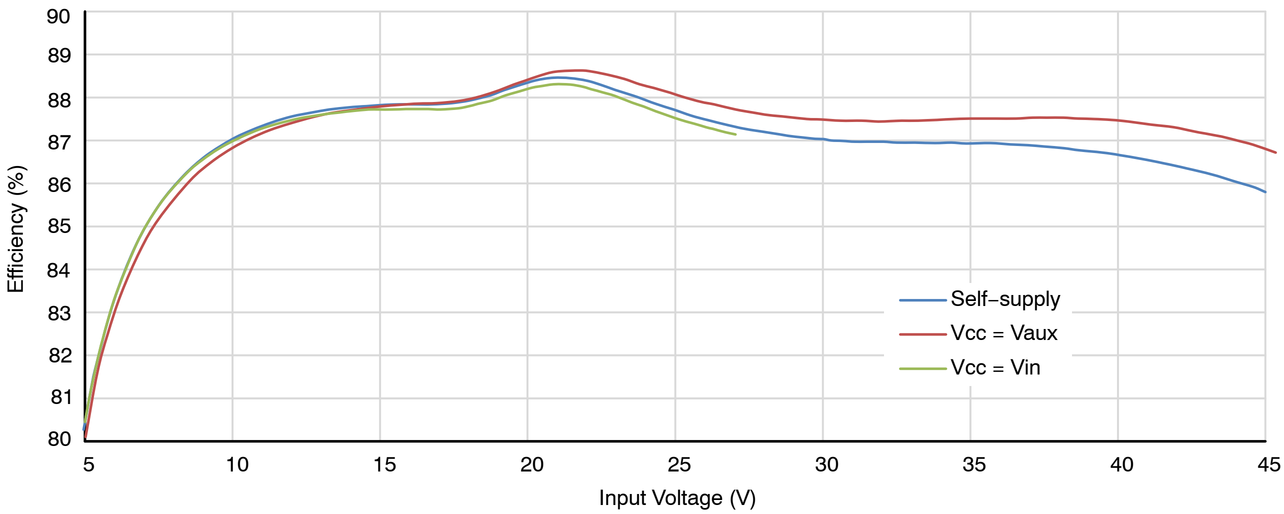

Figure 25. Efficiency vs. Input Voltage for Load Current 1 A

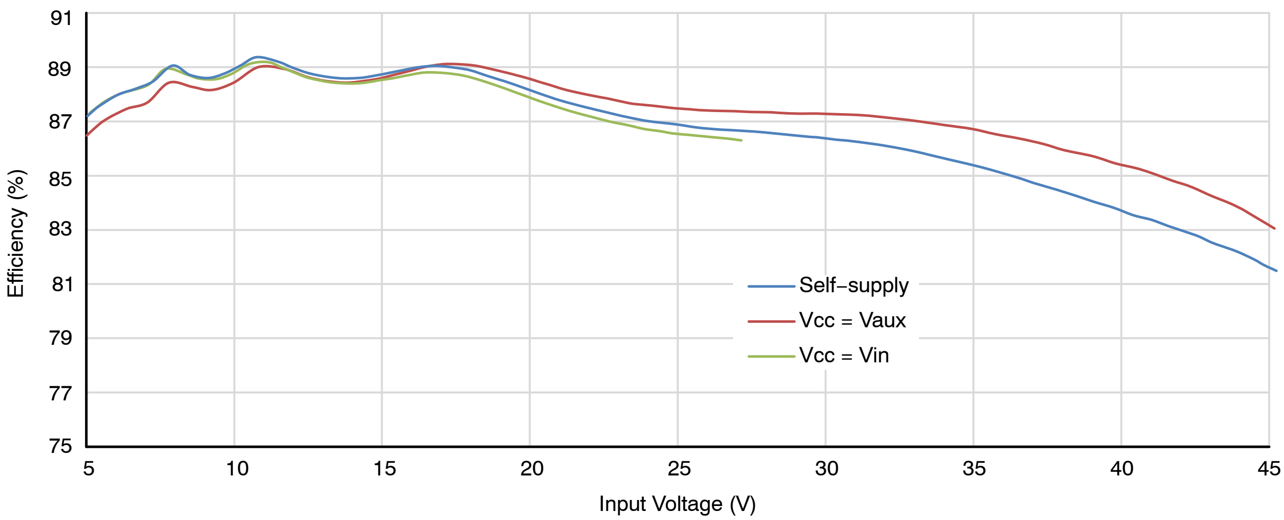

Figure 26. Efficiency vs. Input Voltage for Load Current 0.5 A

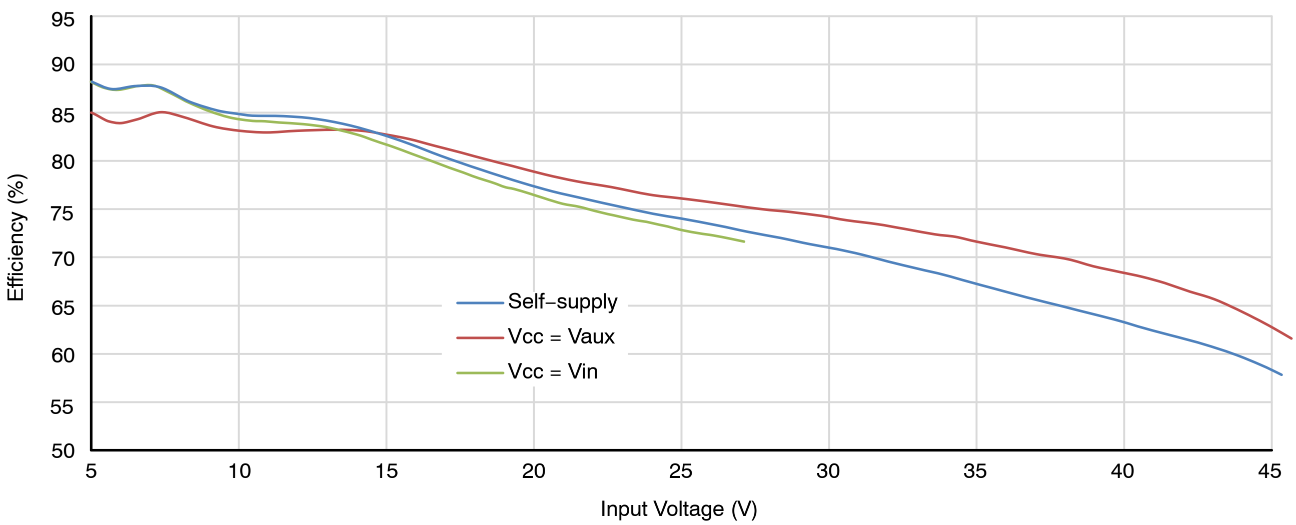

Figure 27. Efficiency vs. Input Voltage for Load Current 0.1 A

Table 4. BILL OF MATERIALS

Designator	Qty	Description	Value	Tolerance	Footprint	Manufacturer	Manufacturer Part Number
C1	1	Ceramic capacitor	10 nF/100 V	20%	0805	Generic	
C2	1	Ceramic capacitor	22 pF/10 V	20%	0805	Generic	
C3	1	Ceramic capacitor	4.7 μF/50 V	10%	1206	TDK	CGA5L3X7R1H475K160AB
C4	1	Ceramic capacitor	10 nF/10 V	10%	0805	Generic	
C5, C13, C14	3	Electrolytic capacitor	330 μF/16 V	20%	TH	Rubycon	16ZLG330MEFC8X11.5
C6	1	Ceramic capacitor	22 nF/10 V	10%	0805	Generic	
C7, C8, C18	3	Ceramic capacitor	0.1 μF/50 V	10%	0805	Generic	
C9	1	Electrolytic capacitor	100 μF/50 V	20%	TH	Rubycon	50ZL100MEFC8X11.5
C10, C11	2	Ceramic capacitor	2.2 μF/100 V	10%	1210	Kemet	C1210C225M1RACTU
C12	1	Electrolytic capacitor	4.7 μF/25 V	20%	TH	Generic	
C15	0	Ceramic capacitor	NU	–	0805	Generic	
C16	1	Ceramic capacitor	1 nF/16 V	10%	0805	Generic	
C17	1	Ceramic capacitor	470 pF/100 V	10%	0805	Generic	
C19	1	Ceramic capacitor	3.3 nF/630 V	10%	1206	Kemet	C1206C332KBRACTU
D1	1	HV diode	1N4937	–	DO−41	**onsemi**	1N4937G
D2	1	Power diode	FSV10120V	–	TO−277	**onsemi**	FSV10120V
D3	1	Signal diode	MMSD914	–	SOD−123	**onsemi**	
D4	1	Signal diode	BAV21	–	SOD−123	**onsemi**	
D5	0	Zener diode 12 V	NU	–	SOD−123	**onsemi**	MMSZ4699T1G
J1a, J2a	2	Banana plug	–	–		multicomp	24.243.1
J1b, J2b	2	Banana plug	–	–		multicomp	24.243.2
L3	1	Inductor	1.5 μH	30%		Coilcraft	MSS1038−152NL
R1	1	Resistor	18 kΩ	1%	2512	Generic	
R2, R13	2	Resistor	40 mΩ	1%	2512	Vishay	WSL2512R0400FEA
R3	1	Resistor	845 Ω	1%	0805	Generic	
R4	1	Resistor	1.5 kΩ	1%	0805	Generic	
R5	1	Resistor	68 kΩ	1%	0805	Generic	
R6, R11, R17	3	Resistor	10 kΩ	1%	0805	Generic	
R7	1	Resistor	133 kΩ	1%	0805	Generic	
R8, R18, R19	0	Resistor	NU	1%	0805	Generic	
R9	1	Resistor	560 Ω	1%	0805	Generic	
R10, R16	2	Resistor	10 Ω	1%	0805	Generic	
R12, R14	2	Resistor	100 Ω/0.5 W	1%	0805	Generic	
R15	1	Resistor	38 Ω	1%	0805	Generic	
R20	1	Resistor	2.2 Ω	1%	0805	Generic	
R21, R100	2	Resistor	0 Ω	1%	0805	Generic	
R22	1	Resistor	1 Ω	1%	0805	Generic	
R23	1	Resistor	33 Ω	1%	0805	Generic	
SW1	1	PCB Switch		–		multicomp	MCNDS−02V
T1	1	Transformer	ZA9654−AE	–		Coilcraft	ZA9654−AE
Q1	1	N−Channel MOSFET	FDMS86103L	–	PQFN−8	**onsemi**	FDMS86103L
U1	1	PWM controller	NCV12711	–	MSOP−10	**onsemi**	NCV12711A
U2	0	Optocoupler	NU	–	SSOP−4	Renesas	
U3	1	Optocoupler	PS2801C−1	–	SSOP−4	Renesas	
U4	1	Shunt Regulator	NCP431	–	SOT−23	**onsemi**	NCP431

ADDITIONAL INFORMATION

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