

# 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  $\mu$ H. The current is sensed via two paralleled 40-m $\Omega$  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 VCC 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<sub>9</sub> is providing that function with its equivalent series resistance (ESR).

# NCV12711SSRGEVB

## 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

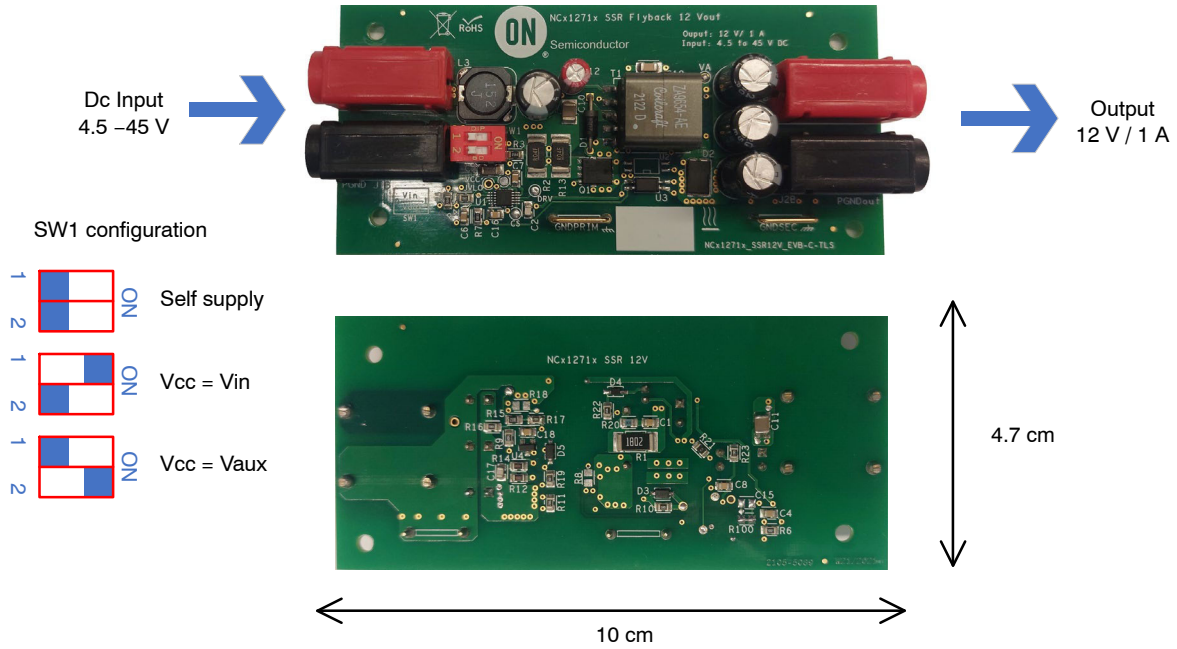


Figure 1. Top/Bottom Photo of the NCV12711SSRGEVB Evaluation Board



# NCV12711SSRGEVB

## MAGNETICS DATA

ZA9654-AE from Coilcraft:

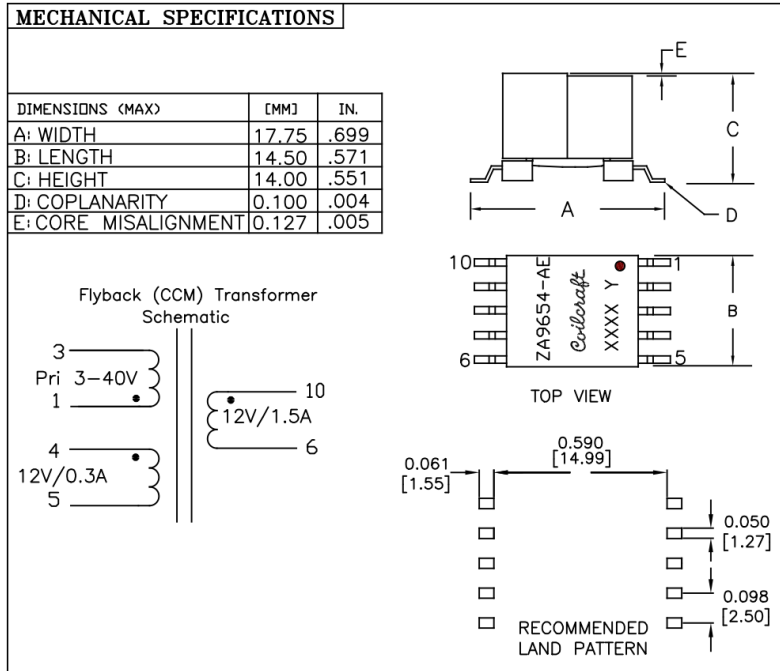


Figure 3. Mechanical Specifications

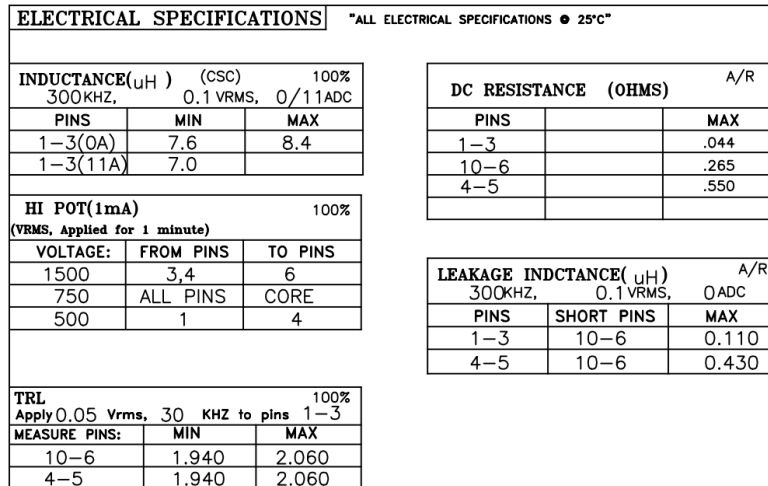


Figure 4. Electrical Specifications

TEST DATA

Startup Time

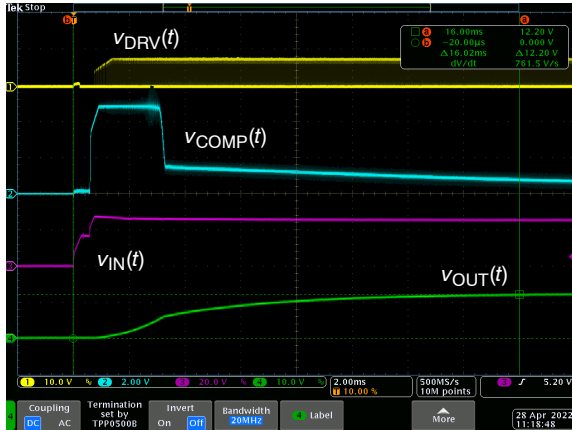


Figure 5. Self-supplied,  $V_{IN} = 25\text{ V}$ ,  $I_{OUT} = 0\text{ A}$ ,  $t_{startup} = 16\text{ ms}$

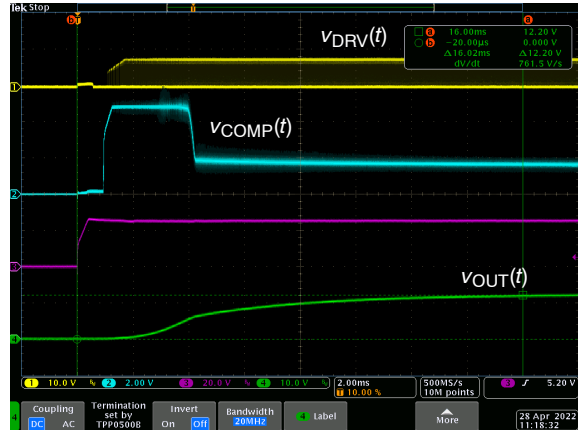


Figure 6. Self-supplied,  $V_{IN} = 25\text{ V}$ ,  $I_{OUT} = 1\text{ A}$ ,  $t_{startup} = 16\text{ ms}$

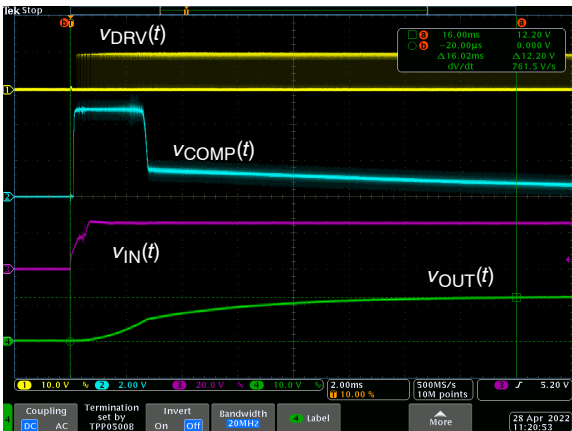


Figure 7. VCC =  $V_{IN}$ ,  $V_{IN} = 25\text{ V}$ ,  $I_{OUT} = 0\text{ A}$ ,  $t_{startup} = 16\text{ ms}$

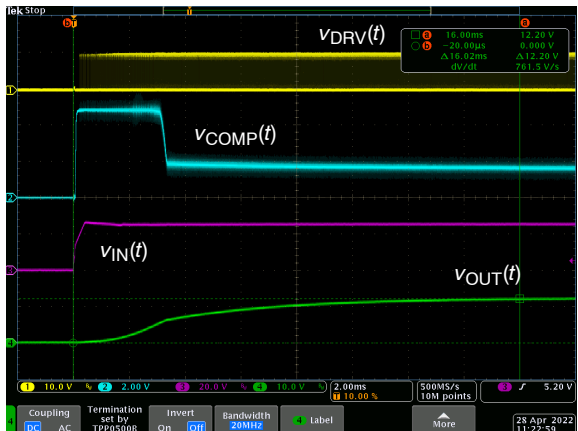


Figure 8. VCC =  $V_{IN}$ ,  $V_{IN} = 25\text{ V}$ ,  $I_{OUT} = 1\text{ A}$ ,  $t_{startup} = 16\text{ ms}$

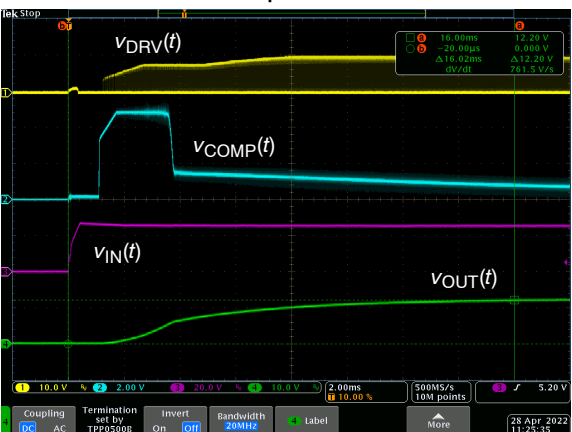


Figure 9. VCC =  $V_{aux}$ ,  $V_{IN} = 25\text{ V}$ ,  $I_{OUT} = 0\text{ A}$ ,  $t_{startup} = 16\text{ ms}$

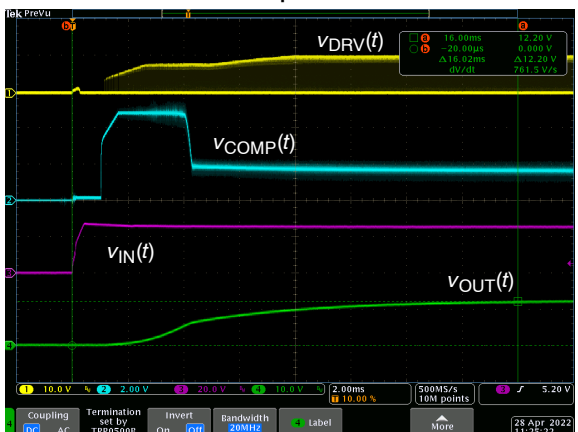


Figure 10. VCC =  $V_{aux}$ ,  $V_{IN} = 25\text{ V}$ ,  $I_{OUT} = 1\text{ A}$ ,  $t_{startup} = 16\text{ ms}$

Steady-state Operation

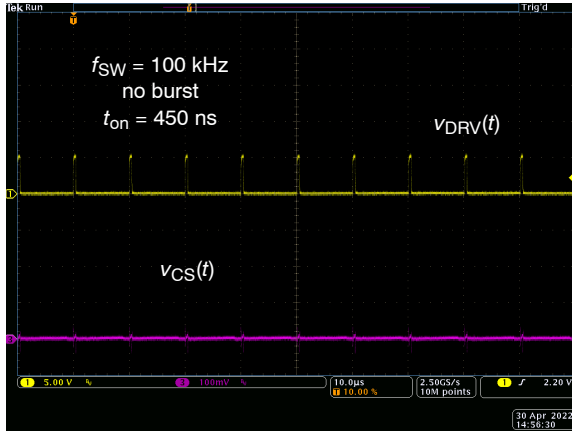


Figure 11.  $V_{IN} = 5.5 \text{ V}$ ,  $I_{OUT} = 0 \text{ A}$

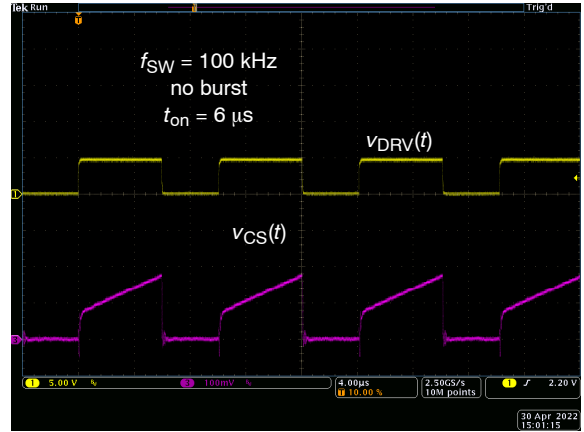


Figure 12.  $V_{IN} = 5.5 \text{ V}$ ,  $I_{OUT} = 1 \text{ A}$

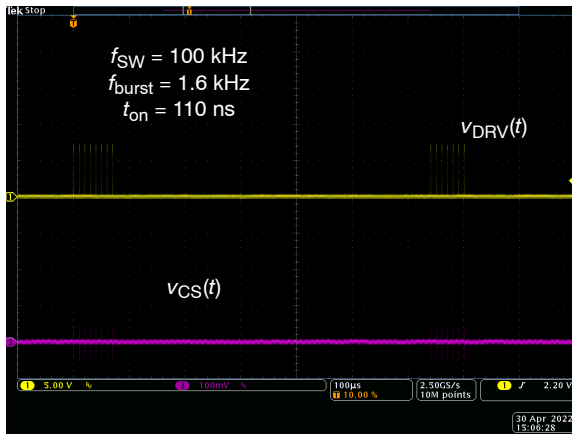


Figure 13.  $V_{IN} = 25 \text{ V}$ ,  $I_{OUT} = 0 \text{ A}$

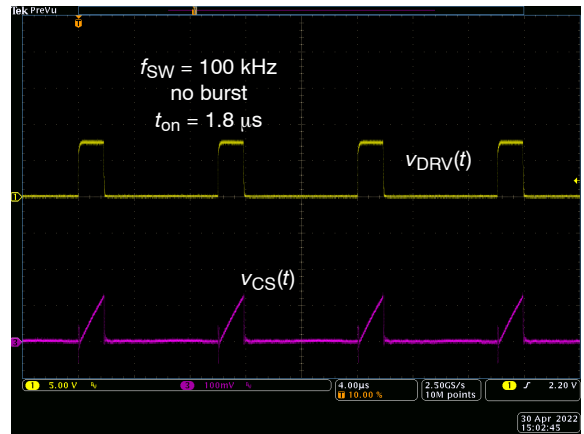


Figure 14.  $V_{IN} = 25 \text{ V}$ ,  $I_{OUT} = 1 \text{ A}$

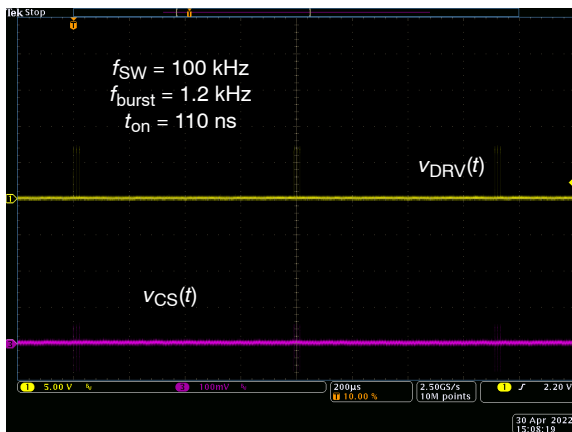


Figure 15.  $V_{IN} = 45 \text{ V}$ ,  $I_{OUT} = 0 \text{ A}$

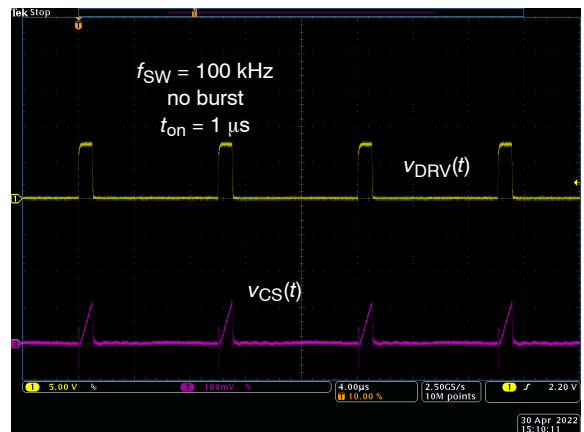


Figure 16.  $V_{IN} = 45 \text{ V}$ ,  $I_{OUT} = 1 \text{ A}$

Load Transient Response

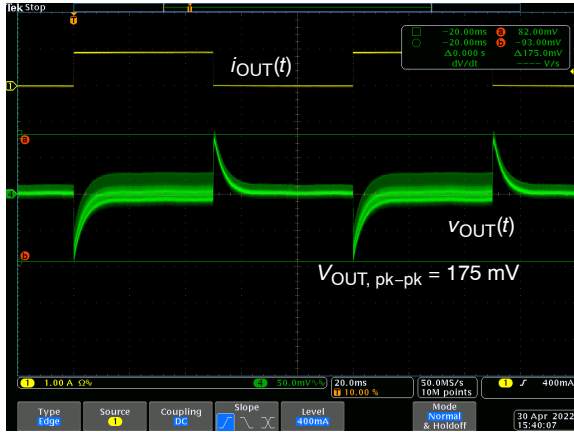


Figure 17.  $V_{IN} = 25\text{ V}$ ,  $I_{OUT} = \text{from } 0.1\text{ A to } 1\text{ A}$ , Slew Rate  $0.5\text{ A}/\mu\text{s}$

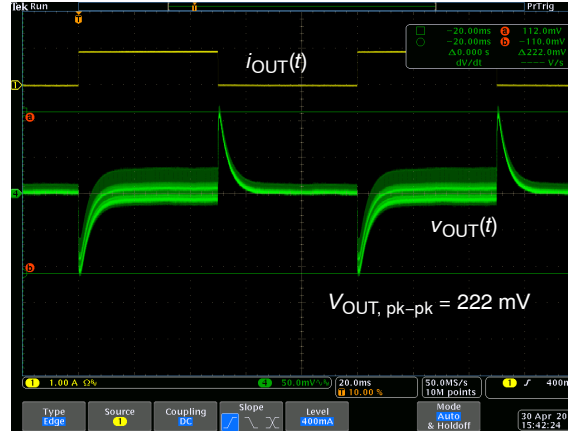


Figure 18.  $V_{IN} = 5.5\text{ V}$ ,  $I_{OUT} = \text{from } 0.1\text{ A to } 1\text{ A}$ , Slew Rate  $0.5\text{ A}/\mu\text{s}$

Output Voltage Ripple

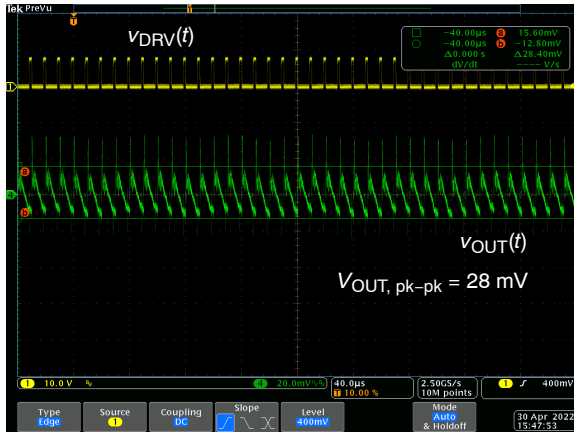


Figure 19.  $V_{IN} = 25\text{ V}$ ,  $I_{OUT} = 1\text{ A}$

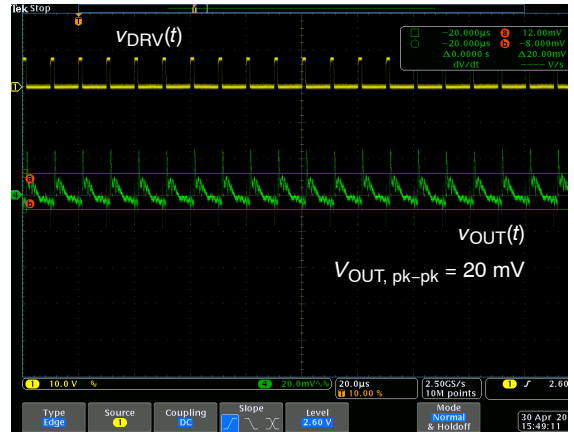


Figure 20.  $V_{IN} = 25\text{ V}$ ,  $I_{OUT} = 0.5\text{ A}$

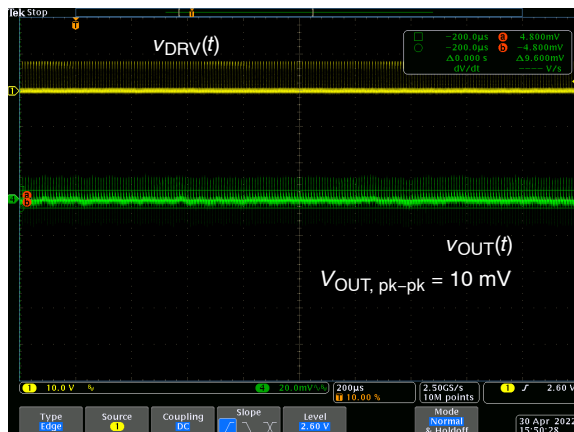


Figure 21.  $V_{IN} = 25\text{ V}$ ,  $I_{OUT} = 0.1\text{ A}$

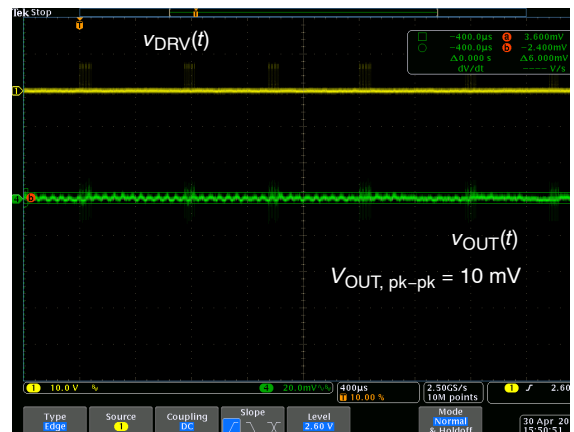


Figure 22.  $V_{IN} = 25\text{ V}$ ,  $I_{OUT} = 0.0\text{ A}$

Drain-Source Voltage

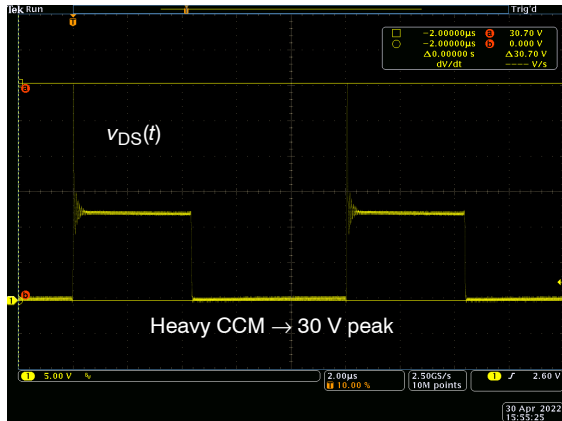


Figure 23.  $V_{IN} = 5.5 \text{ V}$ ,  $I_{OUT} = 1 \text{ A}$

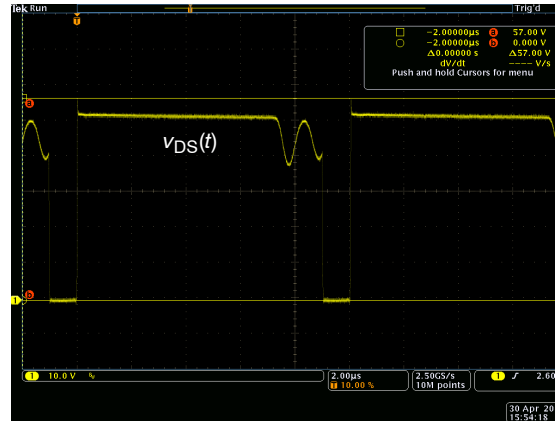


Figure 24.  $V_{IN} = 45 \text{ V}$ ,  $I_{OUT} = 1 \text{ A}$

Standby Data

Table 1. NO-LOAD INPUT POWER WHEN THE IC IS SELF-SUPILED 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



# NCV12711SSRGEVB

## Efficiency Data

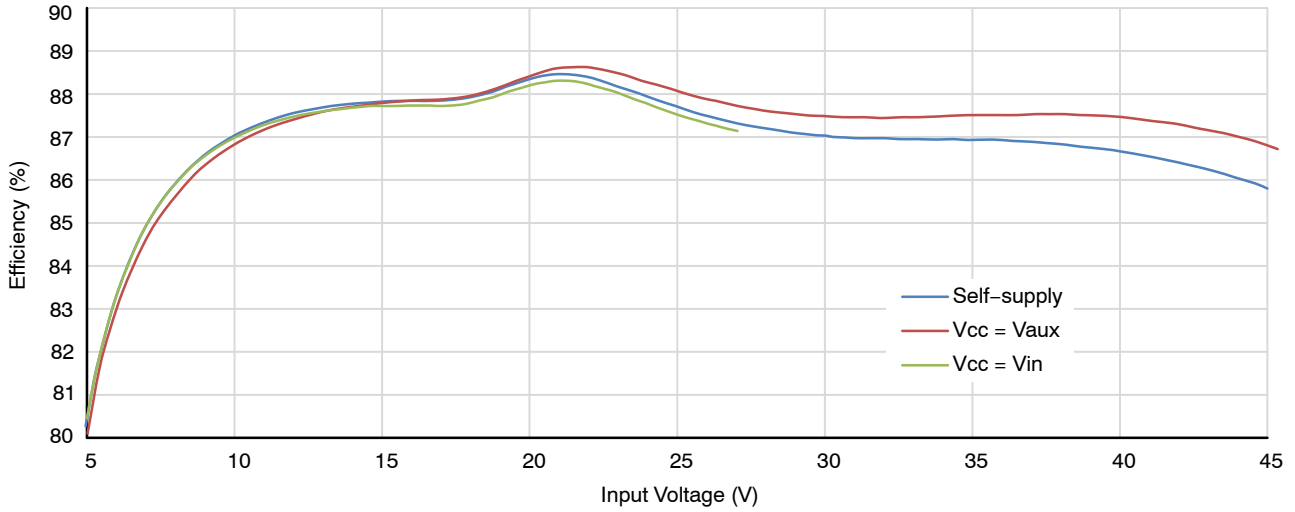


Figure 25. Efficiency vs. Input Voltage for Load Current 1 A

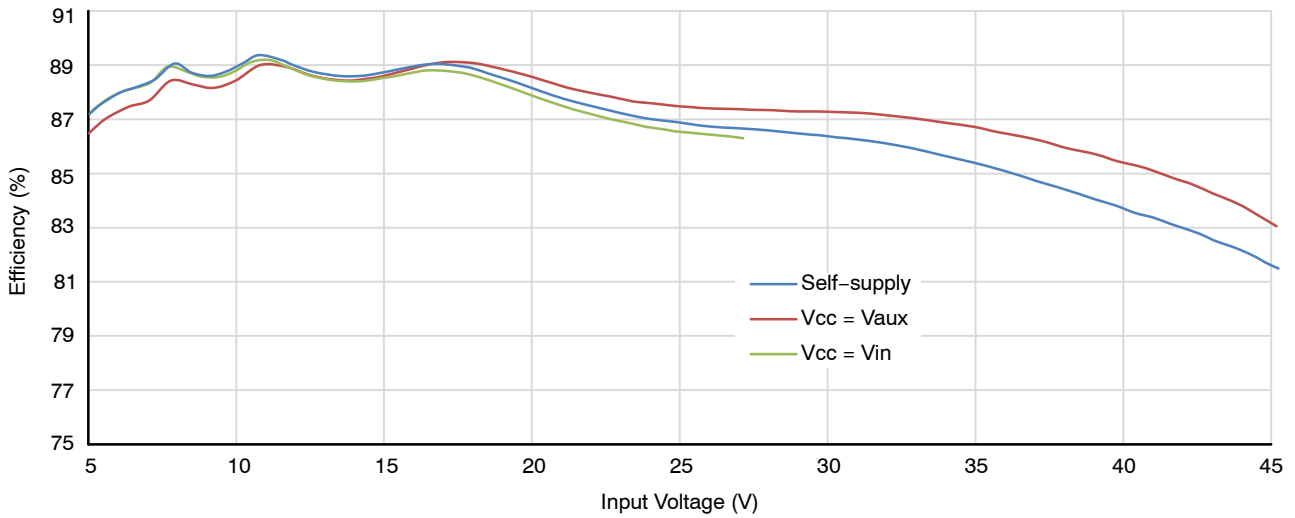


Figure 26. Efficiency vs. Input Voltage for Load Current 0.5 A

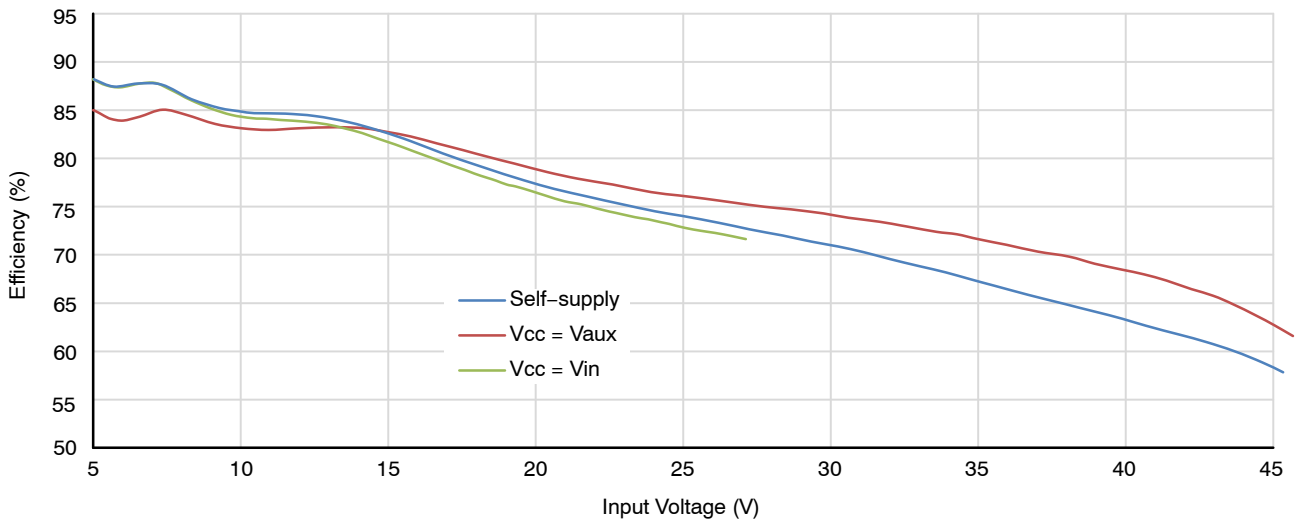


Figure 27. Efficiency vs. Input Voltage for Load Current 0.1 A

# NCV12711SSRGEVB

**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 $\mu$ F/50 V	10%	1206	TDK	CGA5L3X7R1H475K160AB
C4	1	Ceramic capacitor	10 nF/10 V	10%	0805	Generic	
C5, C13, C14	3	Electrolytic capacitor	330 $\mu$ F/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 $\mu$ F/50 V	10%	0805	Generic	
C9	1	Electrolytic capacitor	100 $\mu$ F/50 V	20%	TH	Rubycon	50ZL100MEFC8X11.5
C10, C11	2	Ceramic capacitor	2.2 $\mu$ F/100 V	10%	1210	Kemet	C1210C225M1RACTU
C12	1	Electrolytic capacitor	4.7 $\mu$ F/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	C1206C332KBRCTU
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 $\mu$ H	30%		Coilcraft	MSS1038-152NL
R1	1	Resistor	18 k $\Omega$	1%	2512	Generic	
R2, R13	2	Resistor	40 m $\Omega$	1%	2512	Vishay	WSL2512R0400FEA
R3	1	Resistor	845 $\Omega$	1%	0805	Generic	
R4	1	Resistor	1.5 k $\Omega$	1%	0805	Generic	
R5	1	Resistor	68 k $\Omega$	1%	0805	Generic	
R6, R11, R17	3	Resistor	10 k $\Omega$	1%	0805	Generic	
R7	1	Resistor	133 k $\Omega$	1%	0805	Generic	
R8, R18, R19	0	Resistor	NU	1%	0805	Generic	
R9	1	Resistor	560 $\Omega$	1%	0805	Generic	
R10, R16	2	Resistor	10 $\Omega$	1%	0805	Generic	
R12, R14	2	Resistor	100 $\Omega$ /0.5 W	1%	0805	Generic	
R15	1	Resistor	38 $\Omega$	1%	0805	Generic	
R20	1	Resistor	2.2 $\Omega$	1%	0805	Generic	
R21, R100	2	Resistor	0 $\Omega$	1%	0805	Generic	
R22	1	Resistor	1 $\Omega$	1%	0805	Generic	
R23	1	Resistor	33 $\Omega$	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

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