

# A 12-V/1-A Isolated Flyback Converter with Primary Side Regulation without Auxiliary Winding for Automotive Applications

## Evaluation Board User's Manual

### NCV12711FLOATGEVB

#### SPECIFICATION

Devices	Applications	Input Voltage	Output Power	Topology	Board Size
NCV12711	Automotive	4.5 – 38 V dc	12 W	Current-Mode Flyback	97 x 41 x 15 mm
Output Spec.	Turn On Time	Efficiency	Operating Temperature	Cooling	Standby Power
12 V/1 A	< 100 ms	Peaks to 86 % @ full load	0 – 50°C	Open Frame in Still Air	See the tables on page 7

#### DESCRIPTION

This evaluation board user's manual provides elementary information about a primary side regulated flyback converter NCV12711FLOATGEVB without auxiliary winding 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 the primary winding, avoiding the use of an optocoupler and also an auxiliary winding. The primary winding is first filtered via  $R_{14}/C_{21}$

which help lowering the leakage inductance peak naturally present in the transformer voltage. Then diode  $D_2$  with capacitor  $C_{14}$  provide adequate rectification to build a clean dc voltage as an image of the output voltage.

In order to perform the regulation on the primary winding, the controller is arranged in a floating high-side configuration. In this way, the MOSFET is placed between the input voltage and the transformer. The primary winding is thus directly connected to the negative terminal of the power supply.

The NCV12711 operates in self-supply mode. Due to the reflected voltage from secondary to primary side, the input voltage is limited to 38 V in order to maintain the VIN pin voltage below the 45-V maximum rating.

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.

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.  $C_5$  is providing that function with its equivalent series resistance (ESR).

## NCV12711FLOATGEVB

### 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

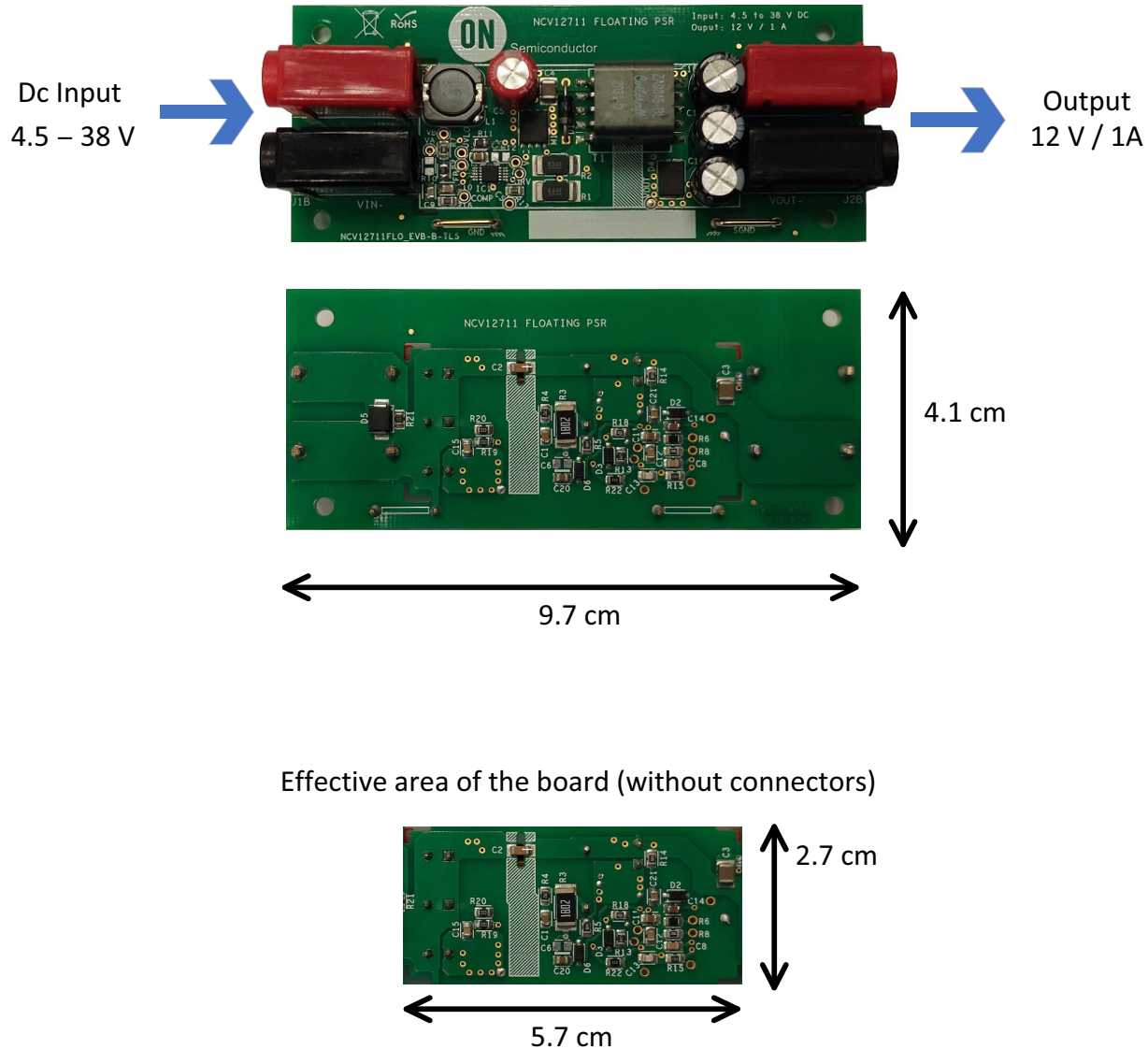
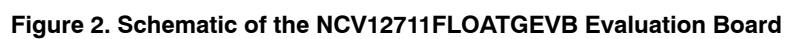


Figure 1. Top/Bottom Photo of the NCV12711FLOATGEVB Evaluation Board

### EVALUATION BOARD SCHEMATIC DIAGRAM



# NCV12711FLOATGEVB

## MAGNETICS DATA

ZA9845-BL from Coilcraft:

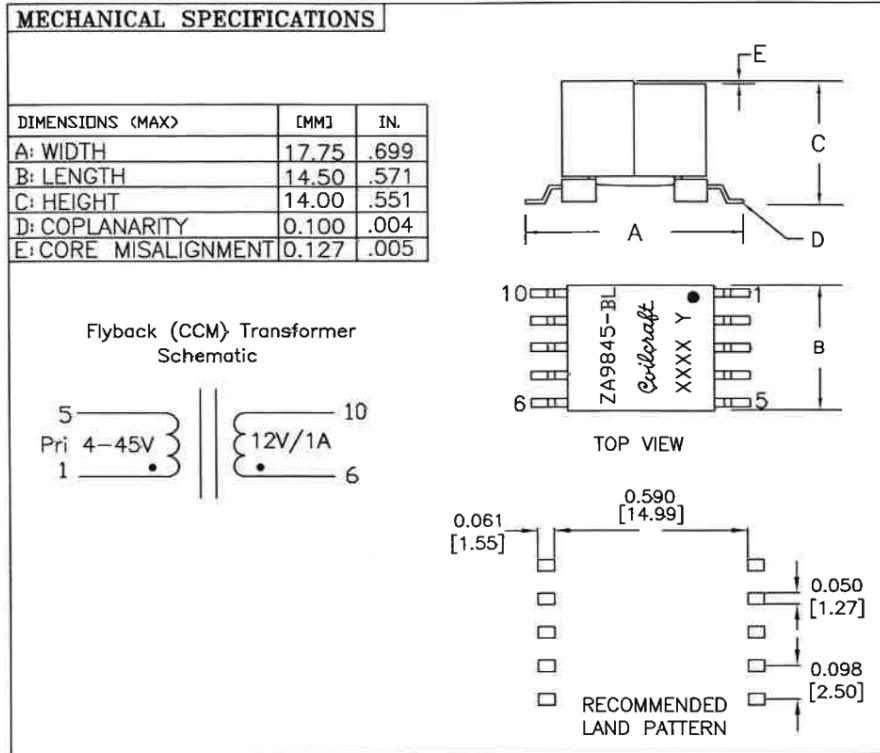


Figure 3. Mechanical Specifications

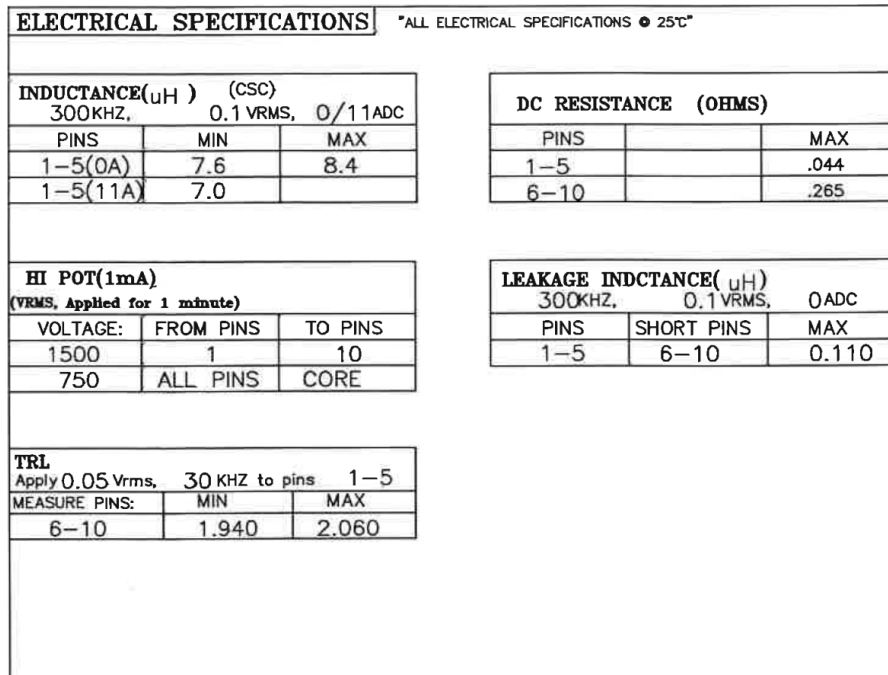


Figure 4. Electrical Specifications

## TEST DATA

### Startup Time

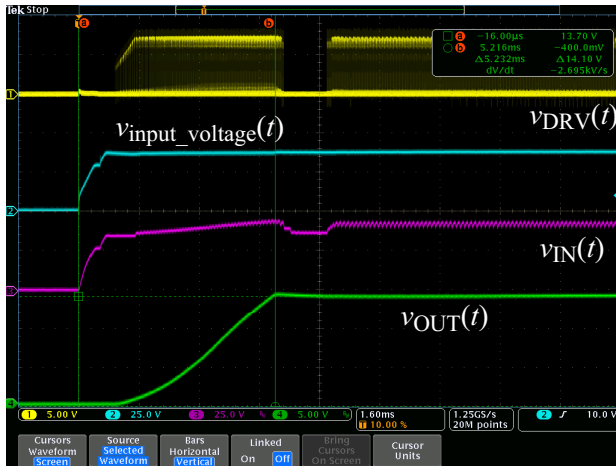


Figure 5. Self-supplied,  $V_{IN} = 38\text{ V}$ ,  $I_{OUT} = 0\text{ A}$ ,  $t_{start} = 5.2\text{ ms}$

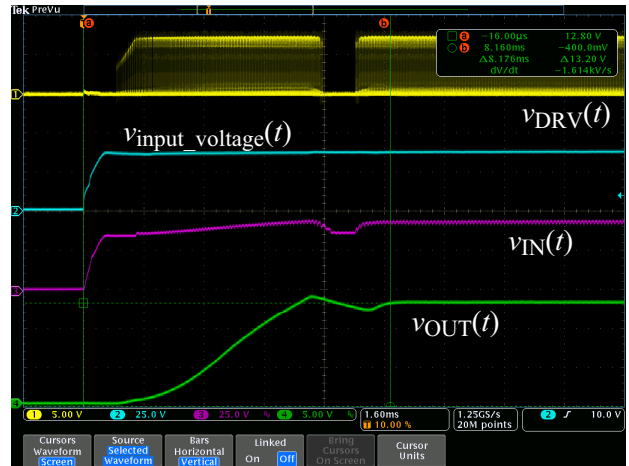


Figure 6. Self-supplied,  $V_{IN} = 38\text{ V}$ ,  $I_{OUT} = 1\text{ A}$ ,  $t_{start} = 8\text{ ms}$

### Steady-state Operation

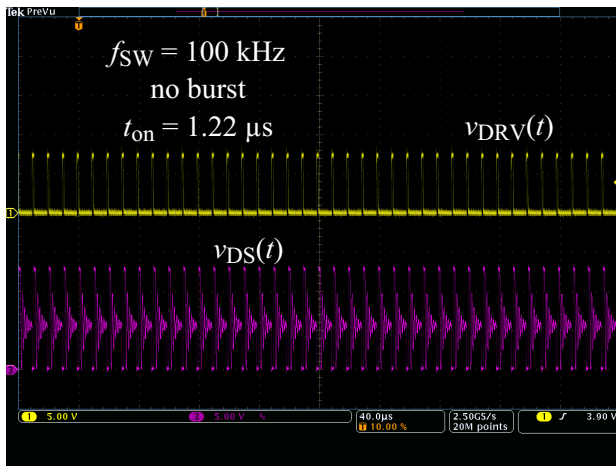


Figure 7.  $V_{IN} = 5.5\text{ V}$ ,  $I_{OUT} = 0\text{ A}$

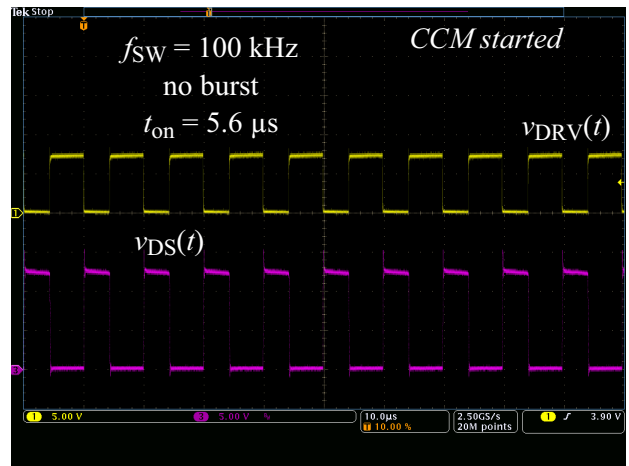


Figure 8.  $V_{IN} = 5.5\text{ V}$ ,  $I_{OUT} = 0.35\text{ A}$

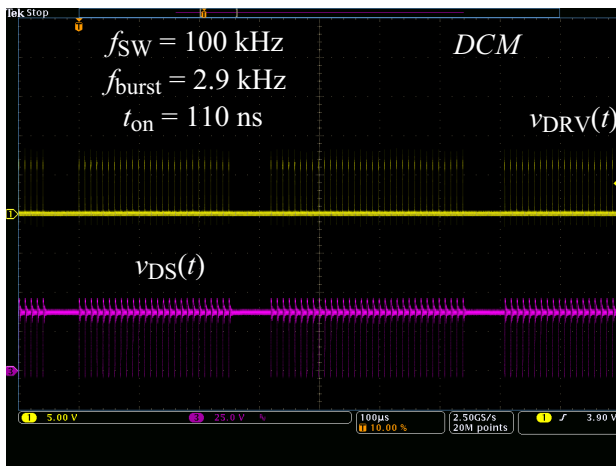


Figure 9.  $V_{IN} = 38\text{ V}$ ,  $I_{OUT} = 0\text{ A}$

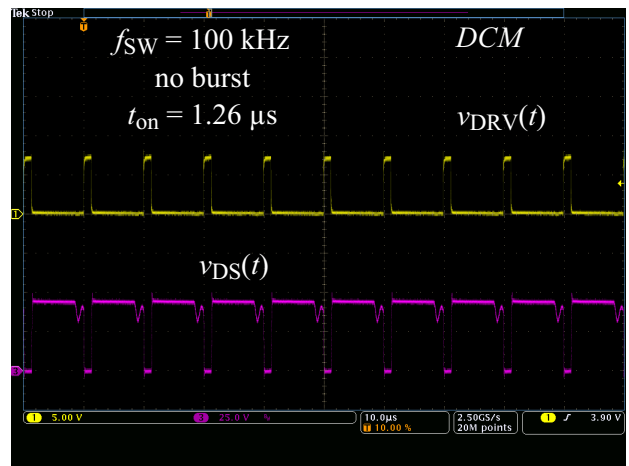


Figure 10.  $V_{IN} = 38\text{ V}$ ,  $I_{OUT} = 1\text{ A}$

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## Load Transient Response

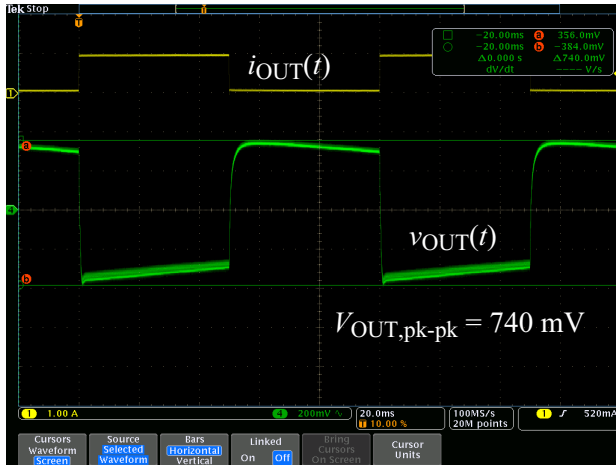


Figure 11.  $V_{IN} = 25\text{ V}$ ,  $I_{OUT} = \text{from } 0.1\text{ A to } 1\text{ A}$ ,  
slew rate  $0.5\text{ A}/\mu\text{s}$

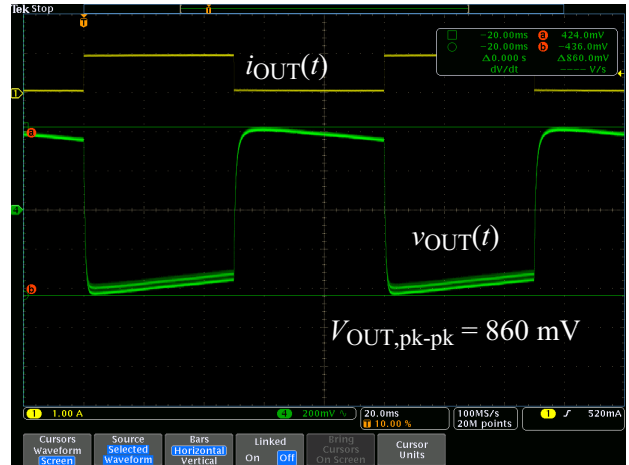


Figure 12.  $V_{IN} = 5.5\text{ V}$ ,  $I_{OUT} = \text{from } 0.1\text{ A to } 1\text{ A}$ ,  
slew rate  $0.5\text{ A}/\mu\text{s}$

## Output Voltage Ripple

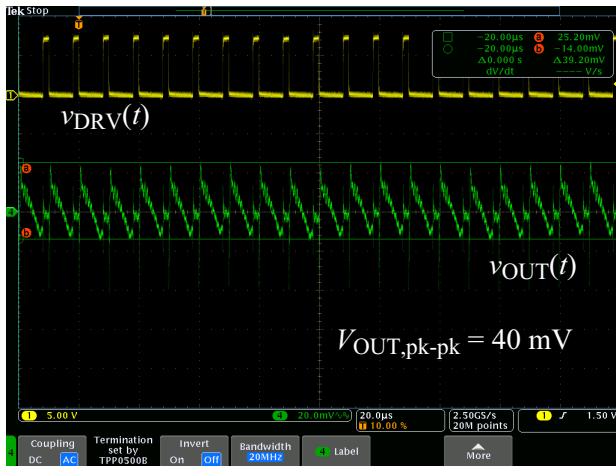


Figure 13.  $V_{IN} = 25\text{ V}$ ,  $I_{OUT} = 1\text{ A}$

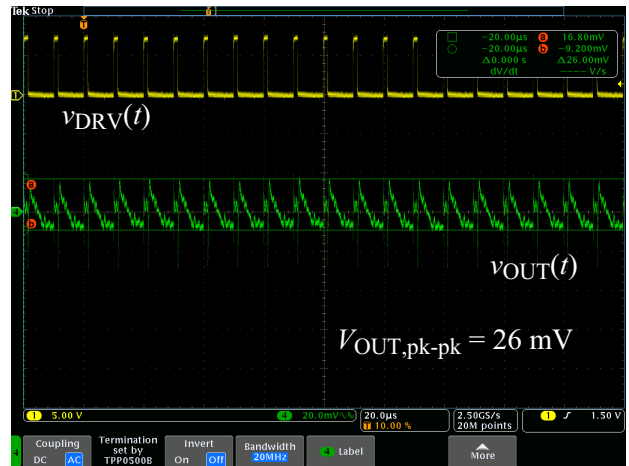


Figure 14.  $V_{IN} = 25\text{ V}$ ,  $I_{OUT} = 0.5\text{ A}$

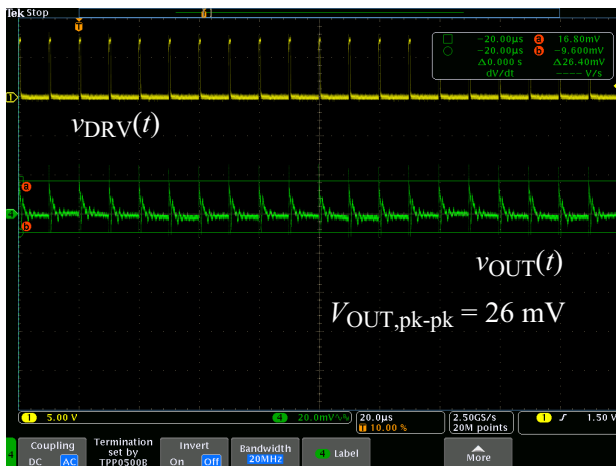


Figure 15.  $V_{IN} = 25\text{ V}$ ,  $I_{OUT} = 0.1\text{ A}$

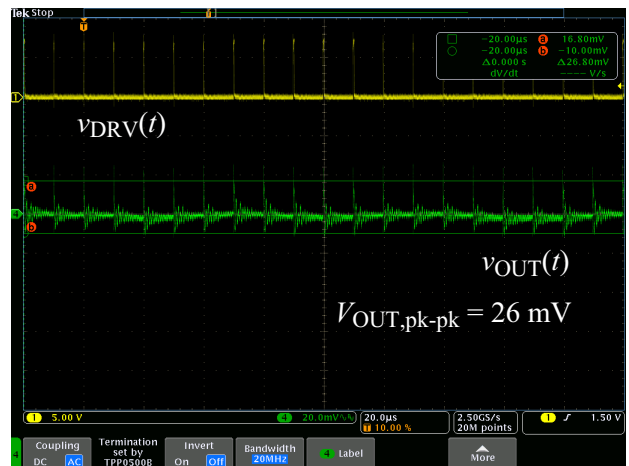


Figure 16.  $V_{IN} = 25\text{ V}$ ,  $I_{OUT} = 0\text{ A}$

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## Drain-Source Voltage

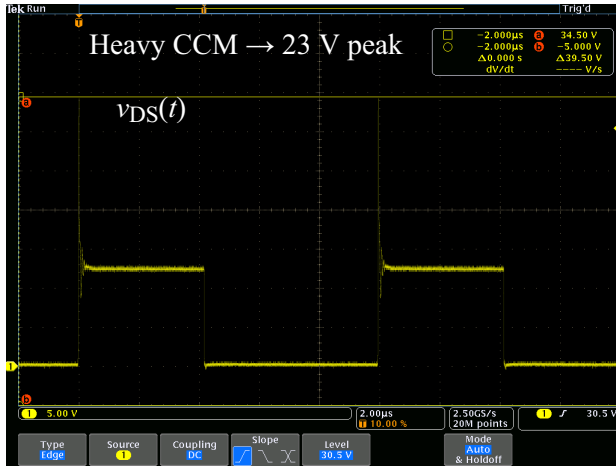


Figure 17.  $V_{IN} = 5.5$  V,  $I_{OUT} = 1$  A

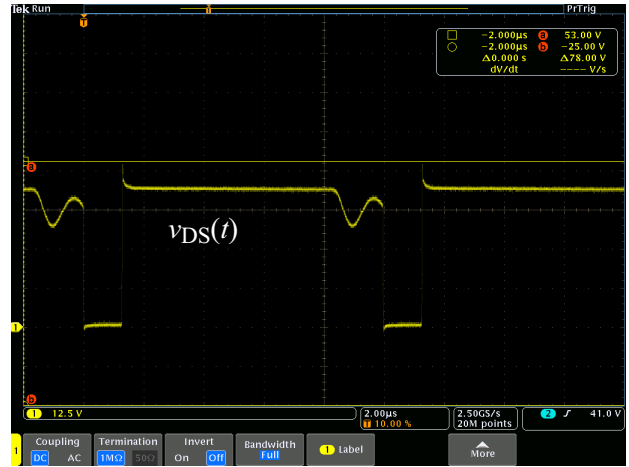


Figure 18.  $V_{IN} = 38$  V,  $I_{OUT} = 1$  A

## Standby Data

Table 1. NO-LOAD INPUT POWER FOR THE BOARD WITHOUT CHANGES (WITH DUMMY LOAD R21 = 1K)

$V_{IN}$ (V)	$I_{IN}$ (mA)	$P_{IN}$ (mW)	$V_{OUT}$ (V)
4.5	74.3	333.4	14.2
12	36.9	406.7	14.3
24	27.9	669.6	14.3
38	24.0	910.1	14.3

Table 2. NO-LOAD INPUT POWER WHEN THE DUMMY LOAD IS REMOVED, OUTPUT IS LOADED BY 5 mA CURRENT SOURCE

$V_{IN}$ (V)	$I_{IN}$ (mA)	$P_{IN}$ (mW)	$V_{OUT}$ (V)
4.5	41.3	186.5	14.7
12	24.4	292.5	14.8
24	20.6	495.5	14.9
38	11.6	440.8	15.3

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## Efficiency Data

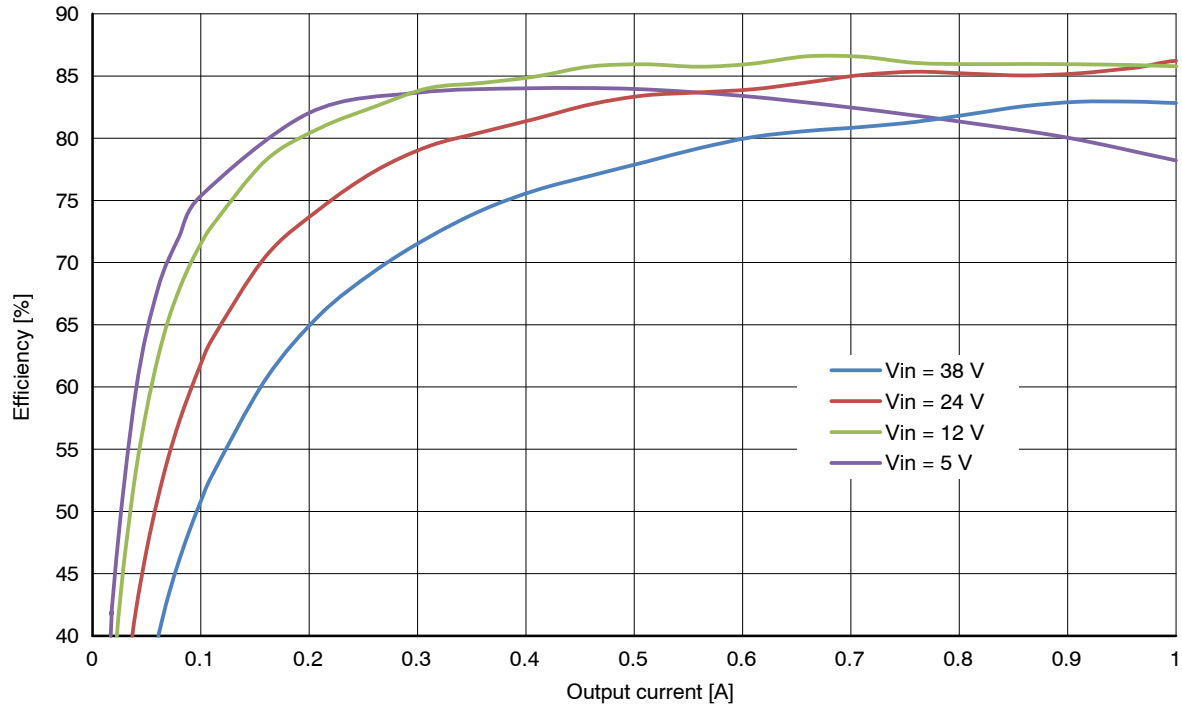


Figure 19. Efficiency vs. Output Current for Constant Input Voltage

## Regulation Data

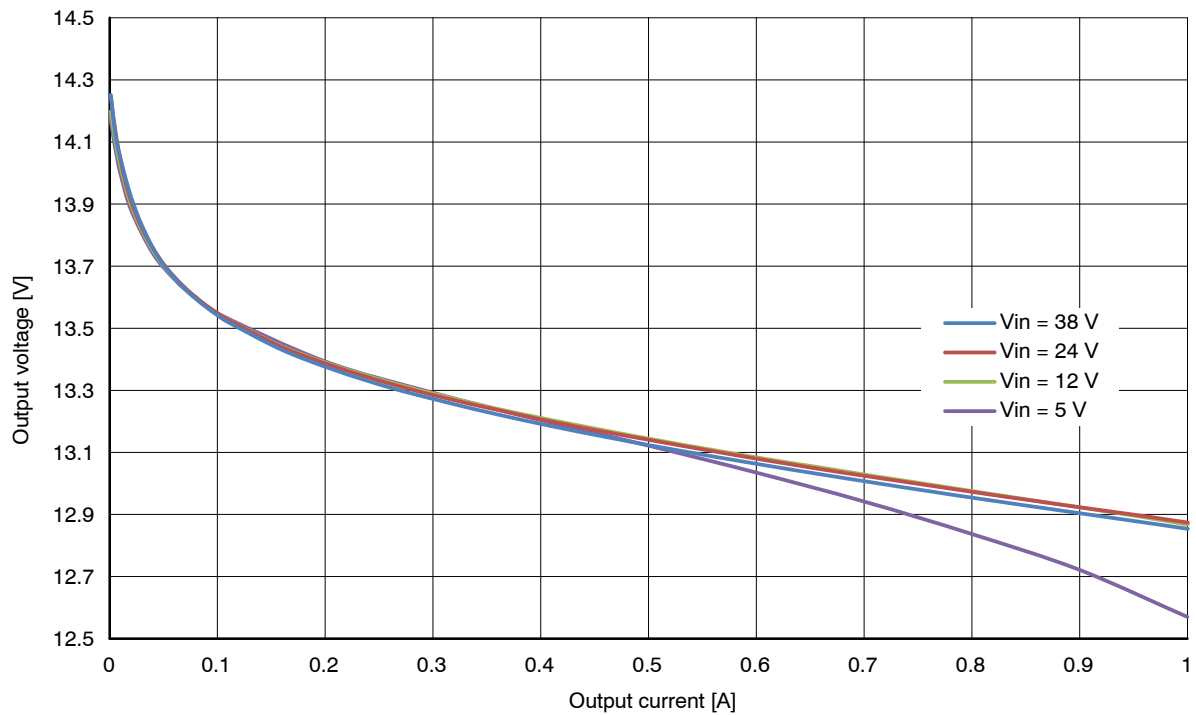


Figure 20. Output Voltage Variation for Constant Input Voltage



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**Table 3. BILL OF MATERIALS**

Part No	Qty	Description	Value	Package	Manufacturer	Manufacturer Part Number
C1	1	Ceramic capacitor	10 nF / 100 V	0805	Generic	
C2	1	Ceramic capacitor	3.3 nF / 630 V	1206	Kemet	C1206C332KBRCTU
C3, C4	2	Ceramic capacitor	2.2 $\mu$ F / 100 V	1210	Kemet	C1210C225M1RACTU
C5	1	Electrolytic Capacitor	100 $\mu$ F / 50 V	TH	Rubycon	50ZL100MEFC8X11.5
C6	0	Ceramic capacitor	NU	0805	Generic	
C7	1	Ceramic capacitor	10 nF / 50 V	0805	Generic	
C8	1	Ceramic capacitor	22 nF / 50 V	0805	Generic	
C9	1	Ceramic capacitor	3.3 nF / 50 V	0805	Generic	
C10	1	Ceramic capacitor	2.2 nF / 50 V	0805	Generic	
C11	1	Ceramic capacitor	4.7 $\mu$ F / 50 V	0805	Generic	
C12	1	Ceramic capacitor	100 nF / 50 V	0805	Generic	
C13	1	Ceramic capacitor	22 pF / 50 V	0805	Generic	
C14	1	Ceramic capacitor	470 nF / 50 V	0805	Generic	
C15	1	Ceramic capacitor, C0G	470 pF / 200 V	0805	Yageo	CC0805JRNPOABN471
C16, C17, C18	3	Electrolytic Capacitor	330 $\mu$ F / 16 V	TH	Rubycon	16ZLG330MEFC8X11.5
C20	1	Ceramic capacitor	1 $\mu$ F / 50 V	0805	Generic	
C21	1	Ceramic capacitor	2.2 nF / 50 V	0805	Generic	
D1	1	HV diode	1N4937	DO-41	onsemi	1N4937G
D2, D3, D6	3	switching diode	MMSD4148	SOD-123	onsemi	MMSD4148
D4	1	power diode	FSV10100V	TO-277	onsemi	FSV10100V
D5	1	Zener diode 15V/3W	1SMB5929BT3G	SMB-2	onsemi	1SMB5929BT3G
IC1	1	PWM Controller	NCV12711	MSOP-10	onsemi	NCV12711ADNR2G
J1a, J2a	2	Banana plug	–	–	multicomp	24.243.1
J1b, J2b	2	Banana plug	–	–	multicomp	24.243.2
L1	1	Inductor	1.5 $\mu$ H	–	Coilcraft	MSS1038-152NL
M1	1	N-channel MOSFET	FDMS86103L	PQFN-8	onsemi	FDMS86103L
R1, R2	2	Resistor	40 m $\Omega$	2512	Vishay	WSL2512R0400FEA
R3	1	Resistor	18 k $\Omega$ / 1 W	2512	Generic	
R4	1	Resistor	2.2 $\Omega$ / 0.5 W	0805	Generic	
R5, R14	2	Resistor	56 $\Omega$	0805	Generic	
R6	1	Resistor	4.7 k $\Omega$	0805	Generic	
R7, R13	2	Resistor	10 $\Omega$	0805	Generic	
R8	1	Resistor	10 k $\Omega$	0805	Generic	
R9	1	Resistor	15 k $\Omega$	0805	Generic	
R10, R12	0	Resistor	NU	0805	Generic	
R11	1	Resistor	22 k $\Omega$	0805	Generic	
R15	1	Resistor	133 k $\Omega$	0805	Generic	
R16	1	Resistor	82 k $\Omega$	0805	Generic	
R17	1	Resistor	820 $\Omega$	0805	Generic	
R18	1	Resistor	10 k $\Omega$	0805	Generic	
R19, R20	2	Resistor	100 $\Omega$ / 0.25 W	0805	Generic	
R21	1	Resistor	1 k $\Omega$ / 0.25 W	0805	Generic	
R22	1	Resistor	0 $\Omega$	0805	Generic	
T1	1	Transformer	ZA9845-BL	–	Coilcraft	ZA9845-BL

NOTES: All parts are Lead-free

Ceramic capacitors are X7R type unless stated otherwise

TH = Through Hole

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