DN0009
Design note

DESIGNS from our LABS

VIPer06X buck regulator, 12V 140 mA

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By John S. Lo Giudice

Main components	
VIPer06	Fixed-frequency VIPer™ plus family
STTH1L06	Turbo 2 ultrafast high voltage rectifier

Specification

- 800V avalanche rugged power section
- PWM operation current mode controller
- Limiting current with adjustable set point
- Fixed frequency with jitter for EMI improvement
- Three operating frequencies:
  - 30 kHz for X type
  - 60 kHz for L type
  - 115 kHz for H type
- Input voltage range:
  - 85V to 265V AC
  - 100V to 375V DC
- Low power application without auxiliary winding
- No load consumption below 30mW @265Vac
- On board soft start
- Auto-restart after a fault condition
- Feedback disconnection protection
- Hysteretic thermal shutdown

Circuit description

This design note describes a non-isolated buck topology regulator using the VIPer06X that supplies a 12V output at up to 140mA. This reference design can be changed to any voltage output by changing R4, the resistor divider off the output, and the compensation RC.

The VIPer06X is a simple device to use. The pin descriptions are helpful in understanding the implementation as shown in Figure 1. For reference, the bill of materials used is shown in Table 1

The circuit can be powered by either 85V to 265V AC or 100V to 375V DC. For the inputs connected to J1, the carbon composition resistor on the input will withstand an input surge. To withstand a 6 kV surge, a wire wound resistor is needed. To meet EMI, C1, L0 and C2 form an input pie filter.

The dip version has two drain pins which are used as a heat sink and the SSO10 has 5 pins on one side for this as well. The drain of the 800 volt MOSFET and the built-in high voltage switched start-up bias current are connected to one of the drain pins. When running, the Viper06 device is able to power itself directly from the rectified mains, eliminating the need for an auxiliary bias winding. For better efficiency and lower stand-by power, a diode, D2, has been added to steer current from the output to the Vdd pin. This works for output voltages ranging from 12V up to 23V. For anything higher than 23V, a zener can be inserted in series with D2 so the Vdd is around 15V. The Vdd pin provides the charging current of the external capacitor during startup and when running from the internal supply.

The LIM pin allows setting the drain current limitation. The limit can be reduced by connecting an external resistor between this pin and GND. The limit pin is left open if the default drain current limitation is used.

The FB pin is the inverting input of the internal trans-conductance error amplifier. Connecting the converter output to this pin through a single resistor results in an output voltage equal to the error amplifier reference voltage or 3.3 volts. The external resistor divider, R4 and R2, sets the output voltage.

The Comp pin is the output of the internal trans-conductance error amplifier. The compensation network has to be placed between this pin and GND to achieve stability and good dynamic performance of the voltage control loop. The linear voltage range extends from VCOMPL to VCOMPH.

The functionality of the Viper06X buck converter, containing an active switch and a floating reference is described below.

After turn on, the internal MOSFET builds energy in inductor L1. When the VIPer06X turns off, the energy stored in L1 continues to flow in the same direction through diode D5 and charges up C6 and the output. D8 charges C4 and gets divided down to 3.3V which goes into the feedback pin and keeps the output regulated.

Figure 1. Circuit diagram

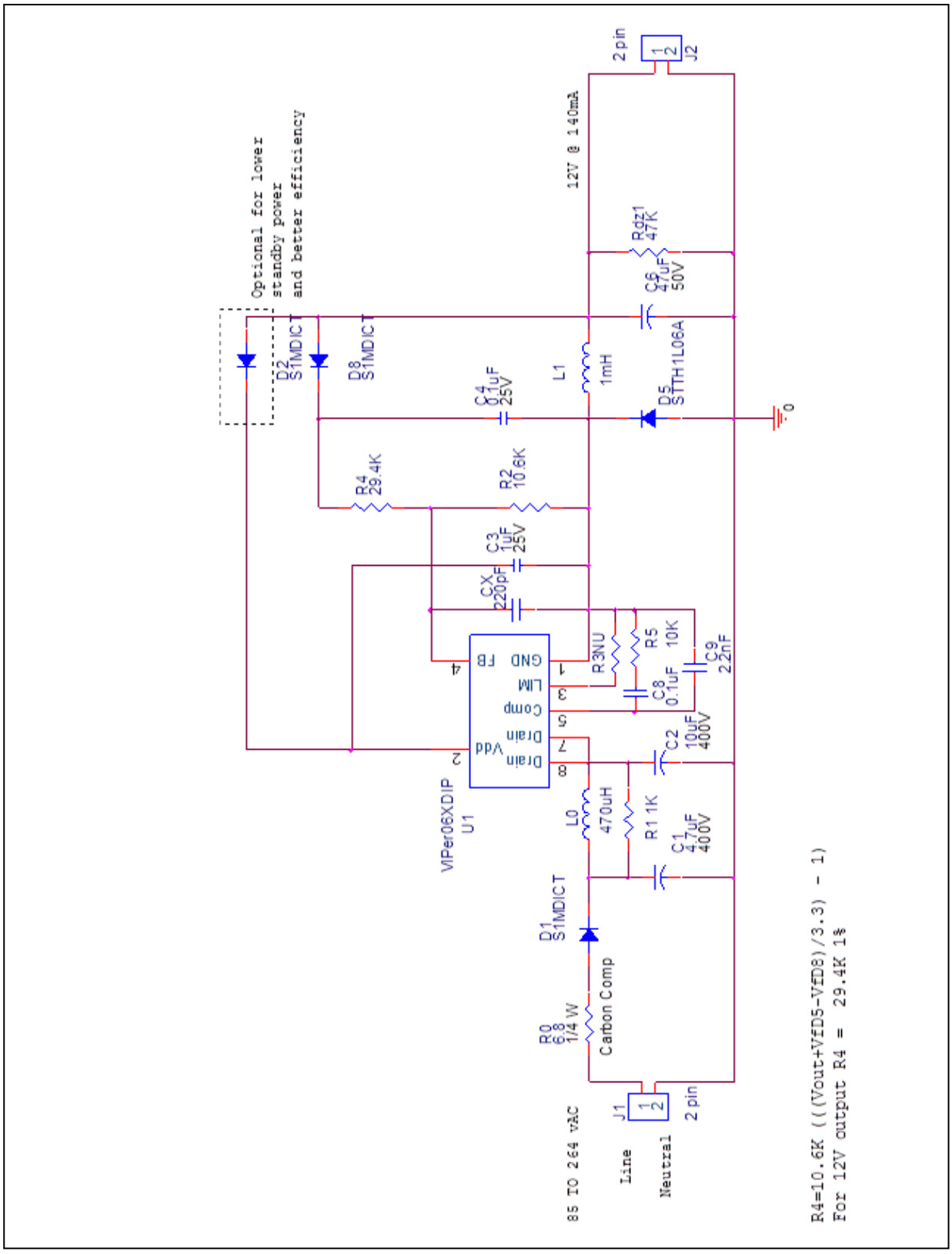


Table 1. Bill of Materials

Item	Qty	Ref.	Part	volt/wat	Descrip.	CAT#
1	1	CX	220pF		X7R +/-10%	
2	1	C1	4.7uF	400V	105 C	Compostar Ltec TKR2GM4R7G16O
3	1	C2	10uF	400V	105 C	Compostar Ltec TKR2GM100G16O
4	1	C3	1uF	25V	X7R +/-10%	TDK C3216X7R1E105K
5	1	C4	0.1uF	25V	X7R +/-10%	TDK C2012X7R1E474K
6	1	C6	47uF	50V	105 C Low ESR	Low ESR
7	1	C8	0.1uF		X7R +/-10%	
8	1	C9	2.2nF		X7R +/-10%	
9	3	D1,D2,D8	S1MDICT		SM GP Diode 1KV 1A	S1MD
10	1	D5	STTH1L06A		600V 1A Ultrfast	**ST**
11	2	J1,J2	2 pin			Mouser 651-1751248
12	1	L0	470uH	140ma		JW Miller 5300-33
13	1	L1	1mH	I sat> 400ma		Compostar Q3277 or Wurth 744772102
14	1	Rdz1	10K	5%		
15	1	R0	6.8	1/4 W	Carbon Comp	0068GJ
16	1	R1	1K	5%	SM0805	
17	1	R2	10.6K	1%	SM0805	
18	1	R3	NU		SM0805	
19	1	R4	29.4K	1%	SM0805	
20	1	R5	NU		SM0805	
21	1	U1	VIPer06X DIP			**ST**

Measurement results

Regulation (10% to 100%) and efficiency at max load, ripple, and stand-by at no load were measured by ST is shown in Table 2.

Table 2. Measured performance

VIPerbuck06X 12V / 140ma 30KHZ with Vdd diode				
Vin	**12V load**	**12V measure**	W in	Efficiency
85Vac	0.014	12.16	0.247	
85Vac	0.14	11.97	2.03	**82.6%**
265Vac	0.014	12.7	0.28	
265Vac	0.14	11.91	2.05	**81.3%**
MIN		11.91		
MAX		12.7		
DELTA		0.79		
Line Reg.		**0.5%**		
+/- % load reg (.03 to max)		**3.3%**		
Ripple	mv pp @ 120Vac		105	
no load @ 265Vac in mw			**40.2 mV**	
over current at 115Vac, Amps extra on top			**0.08 A**	

The conducted EMI measurement for line (purple) and neutral (green) are shown in Figure 2. The peaks are below the limit and the design passed EM55022. Figure 3 shows the efficiency measurement results.

Figure 2. Conducted EMI measurements

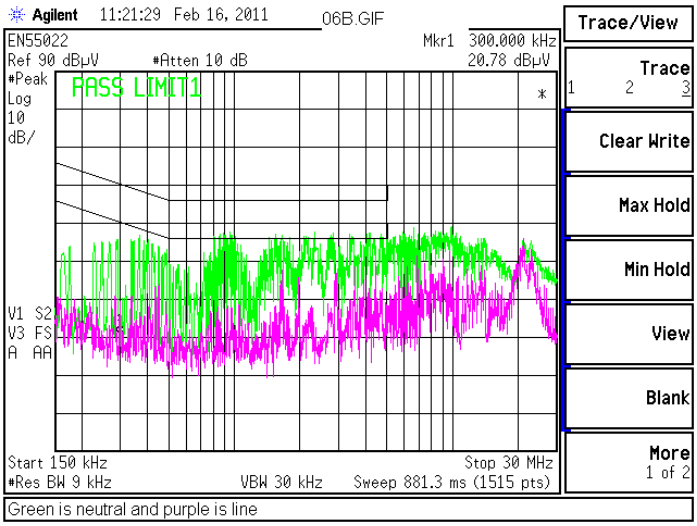
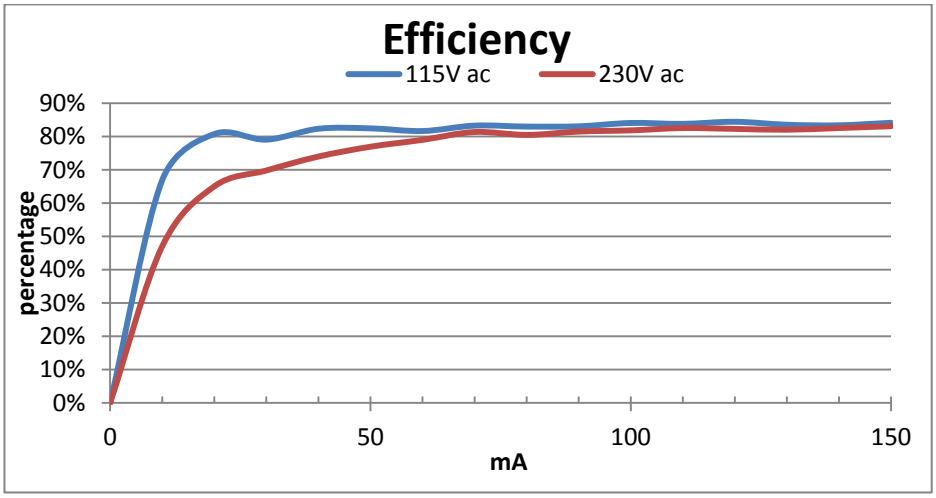
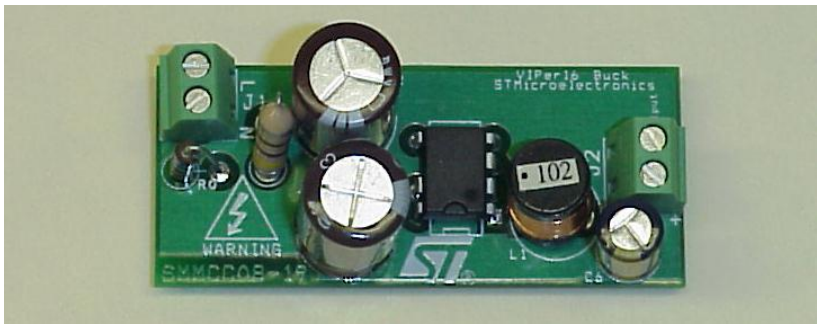


Figure 3. Efficiency measurements



For the evaluation, a VIPer16 circuit board was used since it is pin–for-pin compatible with the VIPer06X as shown in Figure 4.

Figure 4. PCB photo



Support material

Documentation
Datasheet: VIPER06, Fixed-frequency VIPer™ plus family

Revision history

Date	Version	Changes
02-Aug-2012	1	Initial release