

## High voltage converter



## Features

- 730 V avalanche rugged power MOSFET
- PWM controller
- 1.2 V reference voltage
- Frequency jittering
- 40 mW no load input power at 230 V<sub>AC</sub>
- Short-circuit protection
- Thermal shutdown

## Application

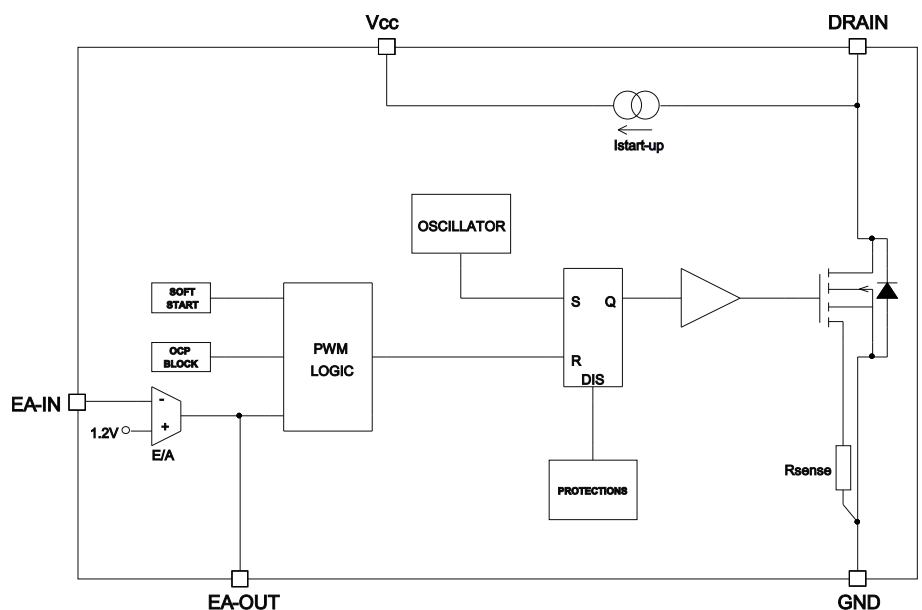
- Auxiliary SMPS for home appliances, consumer, industrial, lighting.

## Description

The VIPER222 device is a high performance high voltage converter that combines a 730 V rugged power MOSFET with a PWM control. The device embeds the high voltage startup and the current sense circuit, avoiding the use of extra components in the BoM. Frequency jittering spreads the EMI and allows the use of a small filter. The burst mode technique allows to obtain a very low input power consumption at light load.

Product status link
<a href="#">VIPER222</a>
Product label


Figure 1. Block diagram



# 1 Pin setting

Figure 2. Connection diagram

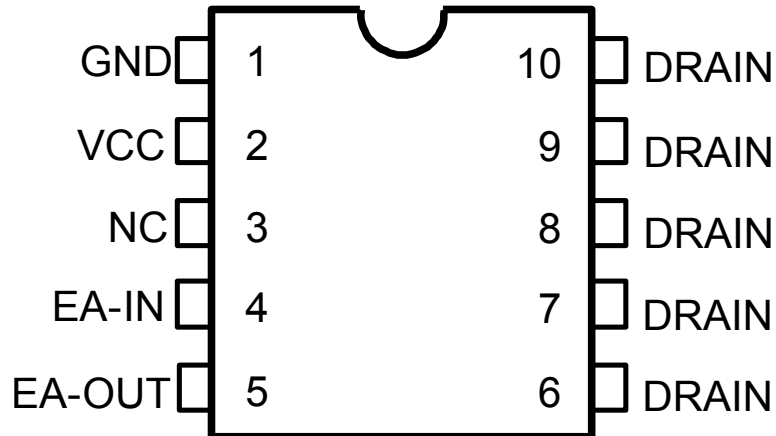


Table 1. Pin description

SSOP10	Name	Function
1	GND	Connected to the source of the internal power MOSFET and controller ground reference.
2	VCC	Supply voltage of the control section. This pin provides the charging current of the external capacitor.
3	NC	Not connected. The pin must be connected to GND pin.
4	EA-IN	Input of the error amplifier.
5	EA-OUT	Output of the error amplifier.
6-10	DRAIN	High voltage drain pin. The start-up bias current is drawn from this pin too. Connect to a PCB copper area to facilitate the heat dissipation.

## 2 Typical power capability

**Table 2. Typical power**

$V_{IN}: 230 V_{AC}$		$V_{IN}: 85 - 265 V_{AC}$	
Adapter <sup>(1)</sup>	Open frame <sup>(2)</sup>	Adapter <sup>(1)</sup>	Open frame <sup>(2)</sup>
11 W	13 W	7 W	8 W

1. Typical continuous power in non-ventilated enclosed adapter measured at 50 °C ambient.
2. Maximum practical continuous power in an open frame design at 50 °C ambient, with adequate heat-sinking

### 3 Electrical and thermal ratings

**Table 3. Absolute maximum rating**

Symbol	Pin	Parameter	Value		Unit
			Min.	Max.	
V <sub>DS</sub>	6-10	Drain-to-source (ground) voltage		730	V
I <sub>D</sub>	6-10	Pulse drain current (limited by T <sub>J</sub> = 150 °C)		2	A
V <sub>EA-IN</sub>	4	Input pin voltage	-0.3	4.8	V
V <sub>EA-OUT</sub>	5	Out pin voltage	-0.3	4.8	V
V <sub>CC</sub>	2	Supply voltage	-0.3	Self limited	V
I <sub>CC</sub>	2	Input current		45	mA
P <sub>TOT</sub>		Power dissipation at T <sub>AMB</sub> < 50 °C		1 <sup>(1)</sup>	W
T <sub>J</sub>		Junction temperature range	-40	150	°C
T <sub>STG</sub>		Storage temperature	-55	150	°C

1. When mounted on a standard single side FR4 board with 100 mm<sup>2</sup> (0.1552 inch) of Cu (35 μm thick)..

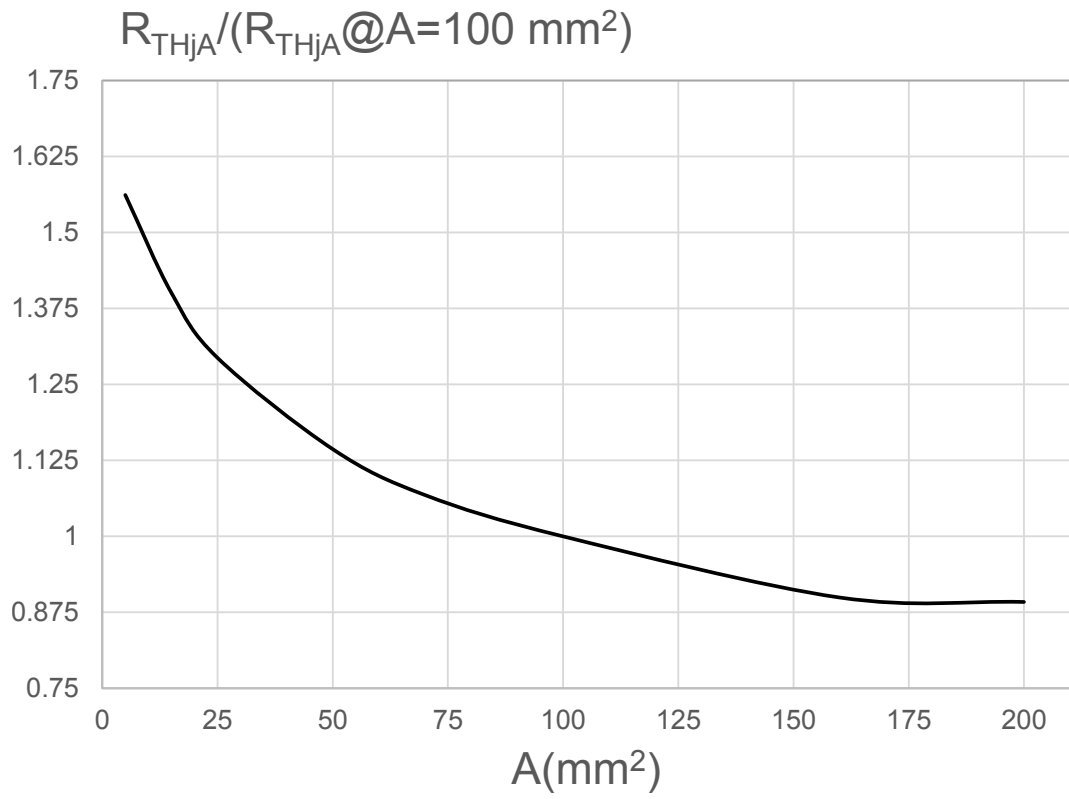
**Table 4. Thermal data**

Symbol	Parameter	Max. value	Unit
R <sub>TH-JC</sub>	Thermal resistance junction to case <sup>(1)</sup> (Dissipated power = 1 W)	10	°C/W
R <sub>TH-JC</sub>	Thermal resistance junction ambient <sup>(1)</sup> (Dissipated power = 1 W)	155	°C/W
R <sub>TH-JC</sub>	Thermal resistance junction to case <sup>(2)</sup> (Dissipated power = 1 W)	5	°C/W
R <sub>TH-JC</sub>	Thermal resistance junction ambient <sup>(2)</sup> (Dissipated power = 1 W)	95	°C/W

1. When mounted on a standard single side FR4 board with minimum copper area.

2. When mounted on a standard single side FR4 board with 100 mm<sup>2</sup> (0.155sq in) of Cu (35 μm thick).

Figure 3. Rth vs. area



## 4 Electrical characteristics

(T<sub>J</sub> = 25 °C, V<sub>CC</sub> = 9 V; unless otherwise specified)

**Table 5. Electrical characteristics**

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
V <sub>BVDSS</sub>	Breakdown voltage	I <sub>D</sub> = 1 mA, EA-OUT= GND	730			V
R <sub>DS(on)</sub>	Drain-Source ON state resistance	I <sub>D</sub> = 0.2 A; T <sub>J</sub> = 25 °C			15	Ω
C <sub>OSS</sub>	Effective (energy related) output capacitance	V <sub>DRAIN</sub> = 100 V		13		pF
I <sub>DSS</sub>	OFF state DRAIN leakage current	V <sub>DRAIN</sub> = 730 V			50	μA
V <sub>START</sub>	Drain-source start voltage				30	V
I <sub>CH1</sub>	Startup charging current	V <sub>DRAIN</sub> = 100 V V <sub>CC</sub> =0 V	-0.6		-1.4	mA
I <sub>CH2</sub>	Charging current during operation	V <sub>DRAIN</sub> = 100 V V <sub>CC</sub> = 6 V	-2		-4	mA
I <sub>CH3</sub>	Charging current during self-supply	V <sub>DRAIN</sub> = 100 V V <sub>CC</sub> = 6 V	-6		-9	mA
V <sub>CC</sub>	Operating voltage range		4.5		30	V
V <sub>CLAMP</sub>	VCC clamp voltage	I <sub>CC</sub> = 35 mA	30			V
V <sub>ON</sub>	VCC ON threshold		15	16	17	V
V <sub>CCL</sub>	VCC low value		4	4.25	4.5	V
V <sub>OFF</sub>	UVLO		3.75	4	4.25	V
I <sub>CC0</sub>	Operating supply current, not switching	Not switching			0.5	mA
I <sub>CC1</sub>	Operating supply current, switching	V <sub>DS</sub> = 150 V V <sub>EA-OUT</sub> = 1.2 V F <sub>OSC</sub> = 30 kHz			1.3	
		V <sub>DS</sub> = 150 V V <sub>EA-OUT</sub> = 1.2 V F <sub>OSC</sub> = 60 kHz			1.6	mA
I <sub>CC_FAIL</sub>	VCC clamp protection		30			mA
I <sub>LIM</sub>	Drain current limit (OCP)	T <sub>J</sub> =25 °C	0.59	0.62	0.65	A
I <sub>LIM_BM</sub>	Drain current limit at low load	T <sub>J</sub> = 25 °C V <sub>EA-OUT</sub> = V <sub>EA_BM</sub>	105	130	155	mA
T <sub>ON(MIN)</sub>	Minimum turn ON time				350	ns
t <sub>RESTART</sub>	Restart time after fault				1.2	s
t <sub>OVL</sub>	Overload delay time				55	ms

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
$t_{OVLmax}$	Maximum overload delay time	VIPER222XSTR $F_{OSC} = F_{OSCmin}$			220	ms
		VIPER222LSTR $F_{OSC} = F_{OSCmin}$			440	
$t_{SS}$	Soft-start time		5		11	ms
$t_{CC\_FAIL}$	Clamp time before shutdown		325	500	675	$\mu s$
$F_{OSC}$	Switching frequency	VIPER222XSTR	27	30	33	kHz
		VIPER222LSTR	54	60	66	
$F_{OSCmin}$	Minimum switching frequency		13.5	15	16.5	kHz
$F_D$	Modulation depth	(1)		$\pm 7$		kHz
$F_M$	Modulation frequency	(1)		260		Hz
$D_{MAX}$	Max. duty cycle	(1)	70		80	%
$V_{REF}$	E/A reference voltage		1.175	1.2	1.225	V
$I_{PULL\ UP}$	EA-IN pin current pull-up			-1		$\mu A$
$G_M$	E/A Trans conductance	(1)		0.5		mA/V
$V_{EA-SAT}$	EA-OUT pin saturation limit			3		V
$V_{EA-BM}$	Burstmode threshold			0.8		V
$R_{DYN}$	Dynamic resistance	$V_{EA-OUT} = 2.7V$ $V_{EA-IN} = GND$		65		k $\Omega$
$H_{EA-OUT}$	$\Delta V_{EA-OUT} / \Delta I_D$	(1)	3.8		7	V/A
$I_{EA-OUT}$	EA-OUT pin source / sink current			100		$\mu A$
$T_{SD}$	Thermal shutdown temperature	(1)	150	160		$^{\circ}C$

1. Specification assured by characterization.

## 5 Typical electrical characteristics

Figure 4.  $I_{LIM}$  vs.  $T_J$

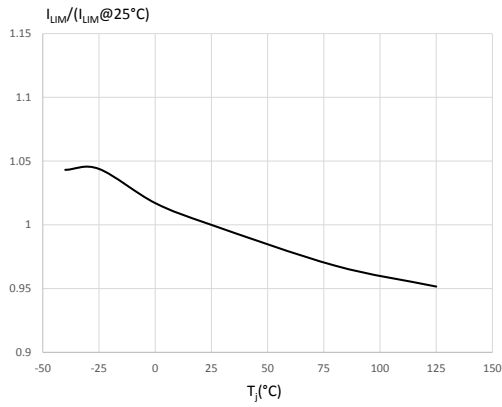


Figure 5.  $V_{REF}$  vs.  $T_J$

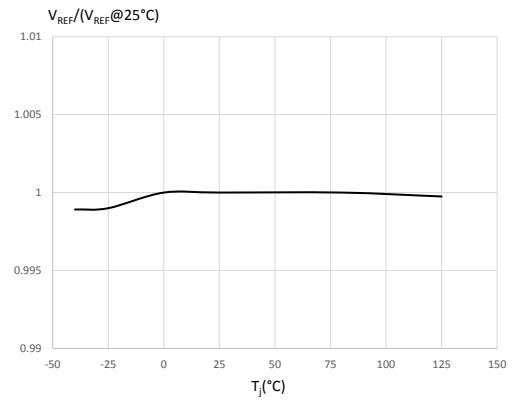


Figure 6.  $I_{CC0}$  vs.  $T_J$

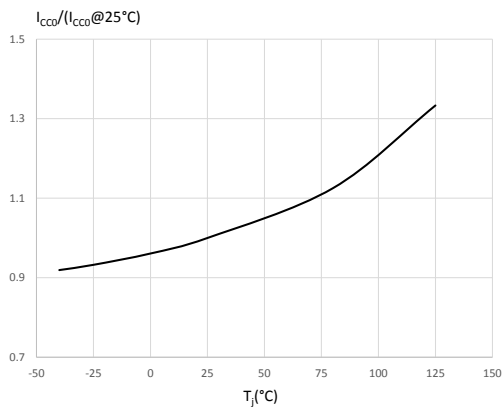


Figure 7.  $I_{CC1}$  vs.  $T_J$

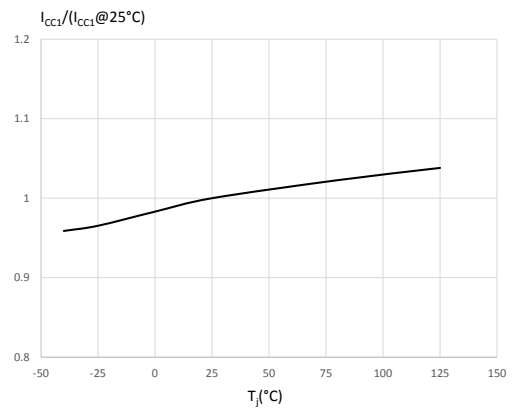


Figure 8.  $R_{DS(on)}$  vs.  $T_J$

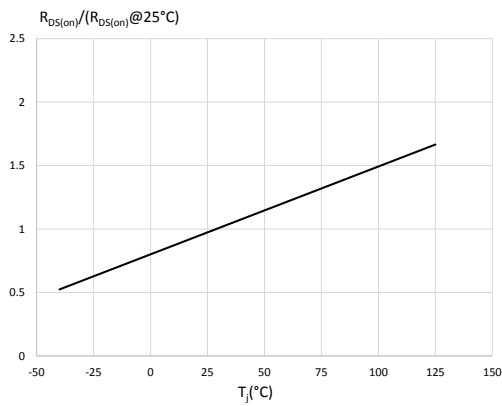
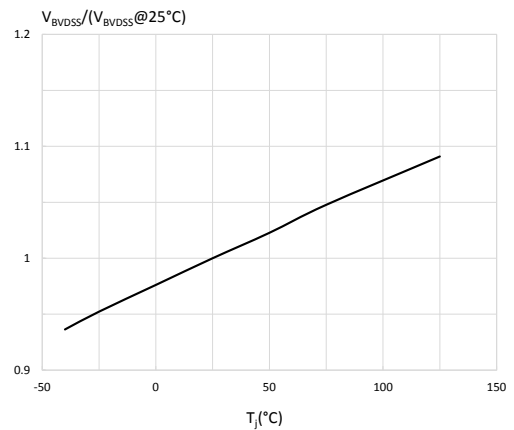


Figure 9.  $V_{BVDSS}$  vs.  $T_J$





## 6 General description

VIPER222 is a 730 V high voltage converter optimized for flyback and buck topologies that operates at 60 kHz (L type) or 30 kHz (X type) switching frequency and integrates the jittering feature in order to reduce the EMI level.

The low IC consumption combined with the burst mode technique allow to obtain very low input power at no load and very good efficiency at light load.

### 6.1 Startup

At the first startup the integrated high voltage current source charges the VCC capacitor. At the beginning of startup, when the capacitor is fully discharged, the charging current is low,  $I_{CH1}$ , in order to avoid IC damaging in case  $V_{CC}$  is accidentally shorted to GND. As  $V_{CC}$  exceeds 1 V,  $I_{CH1}$  is increased to  $I_{CH2}$  in order to speed up the charging. The charge current is stopped as soon as  $V_{CC}$  reaches  $V_{ON}$ .

As soon as the VCC capacitor is charged up to  $V_{ON}$ , the high voltage current source is disabled, the device is powered by the energy stored in the capacitor and the primary MOSFET starts switching.

The internal soft-start function of the device progressively increases the cycle-by-cycle current limitation set point from zero up to  $I_{LIM}$  in 8 steps. The soft-start time,  $t_{SS}$ , is internally set at 8 ms. This function is activated at any attempt of converter startup and at any restart after a fault event.

### 6.2 Feedback loop

The device operates in current mode, so the primary current is internally sensed and converted in voltage that is applied to the non-inverting pin of the PWM comparator. The sensed voltage is compared through a voltage divider and on cycle-by-cycle basis with the one present on the EA-IN pin.

The OCP comparator works in parallel with the PWM comparator and it limits the primary current below the  $I_{LIM}$  threshold.

There are two ways to close the loop and get the output regulated: through resistor divider or through external error amplifier plus optocoupler

#### Resistor divider

For non-isolated topologies (fly-back, buck or buck-boost converters) the output voltage can be directly set connecting a resistor divider (referenced to GND pin) between the converter output and the EA-IN pin, which is the inverting input of the integrated error amplifier (EA).

Primary side regulation can be realized connecting the resistor divider between VCC, EA-IN and GND pins.

The loop compensation network is connected across EA-OUT and GND pins.

#### External error amplifier plus optocoupler

In case of isolated fly-back, EA-IN must be connected to GND, which disables the internal error amplifier, and the output voltage is set through an external error amplifier (TL431 or similar) placed on the secondary side. Its error signal, reported to the primary through an optocoupler, is used to set the EA-OUT pin voltage to the value corresponding to the DRAIN peak current required by the control loop to deliver the given output power.

The EA-OUT pin dynamics range between the values  $V_{EA-BM}$  and  $V_{EA-SAT}$ : below the  $V_{EA-BM}$  level the device enters burst mode; above the  $V_{EA-SAT}$  level, the primary drain current reaches its limit  $I_{LIM}$ .

### 6.3 Pulse skipping

The protection is intended to avoid the so called "flux-runaway" condition often present at converter startup, because of the low output voltage, and due to the fact that the primary MOSFET, cannot be turned off before the minimum on-time. During the on-time, the inductor is charged by the input voltage and if it cannot be discharged by the same amount during the off-time, in every switching cycle there is a net increase of the average inductor current, that can reach dangerously high values.

Thanks to this protection, each time the DRAIN peak current exceeds  $I_{LIM}$  level within  $t_{ON\_MIN}$ , one switching cycle is skipped. The cycles can be skipped until the minimum switching frequency  $F_{OSCmin}$  (15 kHz typ.) is reached. Each time the DRAIN peak current does not exceed  $I_{LIM}$  within  $t_{ON\_MIN}$ , one switching cycle is restored. The cycles can be restored until the nominal switching frequency is reached,  $F_{OSC}$  (30 or 60 kHz).

## 6.4 Burst mode at light load

When the load decreases, the feedback loop reacts lowering the EA-OUT pin voltage. If it goes below the  $V_{EA-BM}$  threshold, the DRAIN peak current is reduced to  $I_{LIM\_BM}$ , avoiding audible noise which could arise from low switching frequency. When the load is increased,  $V_{EA\_OUT}$  increases. As it reaches the  $V_{EA\_SAT}$  threshold, the DRAIN peak current reaches its maximum value,  $I_{LIM}$ .

## 6.5 Short-circuit protection

In case of overload or short-circuit on the output, the IC runs at  $I_{LIM}$ .

If this condition is removed before 50ms, the IC continues its normal operation.

If this condition lasts for  $t_{OVL}$  (50ms, typ.), the protection is tripped, the device stops switching for  $t_{RESTART}$  (1 sec. typ.), then resumes switching with soft-start phase. If the fault is still present, after  $t_{OVL}$ , the IC is disabled again for  $t_{RESTART}$ ; otherwise it resumes normal operation.

If the converter is definitively operated at  $F_{OSC\_MIN}$ , (see [Section 6.3](#)), the overload time will increase to  $t_{OVL\_MAX}$  (100 ms typ. for VIPER222XSTR; 200 ms typ. for VIPER222LSTR).

During the fault event, the VCC voltage is maintained between  $V_{CCL}$  (4.25 V) and  $V_{ON}$  (16 V) by the periodical activation of the high voltage current source.

## 6.6 VCC clamp protection

If  $V_{CC}$  reaches the clamp level  $V_{CLAMP}$  and the current injected into the pin exceeds the internal threshold  $I_{CC\_FAIL}$  for more than  $t_{CC\_FAIL}$ , a fault condition is detected. The PWM is disabled for  $t_{RESTART}$  and then activated again in soft-start phase. The protection is disabled during the soft-start time.

## 7 Basic application schematics

Figure 10. Non isolated flyback converter

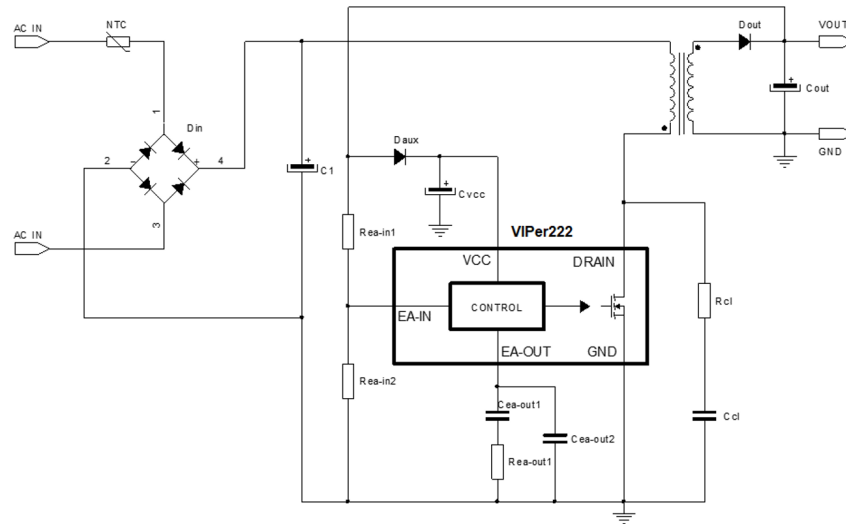


Figure 11. Primary side flyback converter

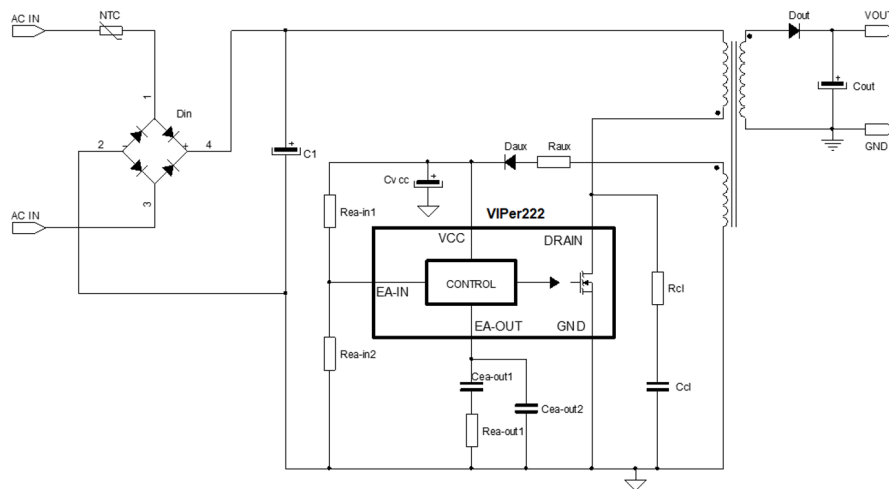


Figure 12. Isolated flyback converter

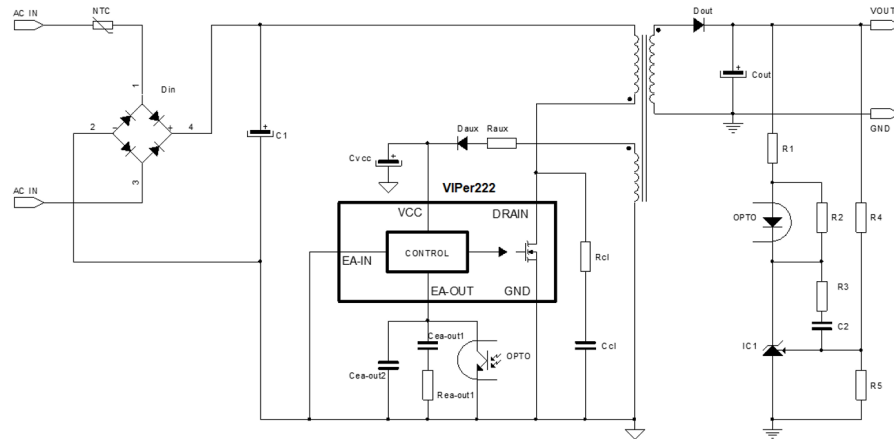


Figure 13. Buck converter

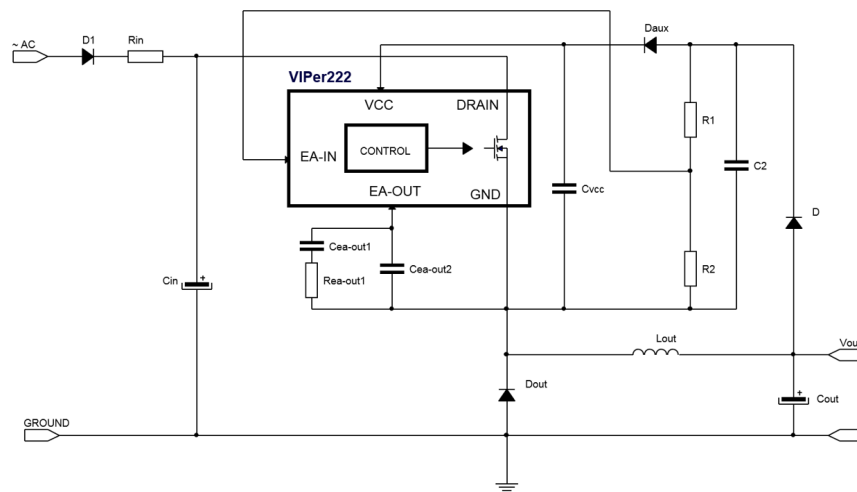
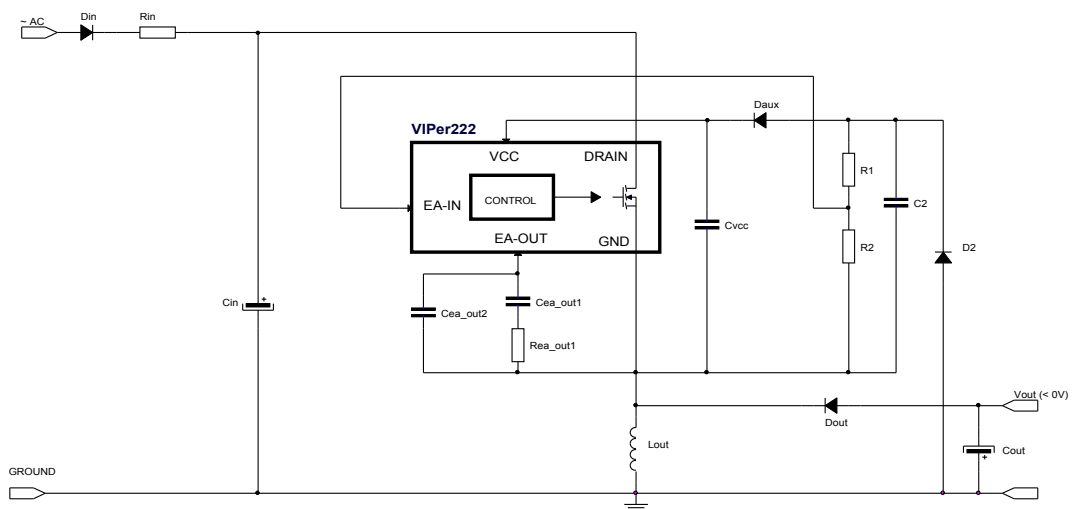


Figure 14. Buck-Boost converter



## 8 Package information

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK® packages, depending on their level of environmental compliance. ECOPACK® specifications, grade definitions and product status are available at: [www.st.com](http://www.st.com).

ECOPACK® is an ST trademark.

### 8.1 SSOP10 package information

Figure 15. SSOP10 package outline

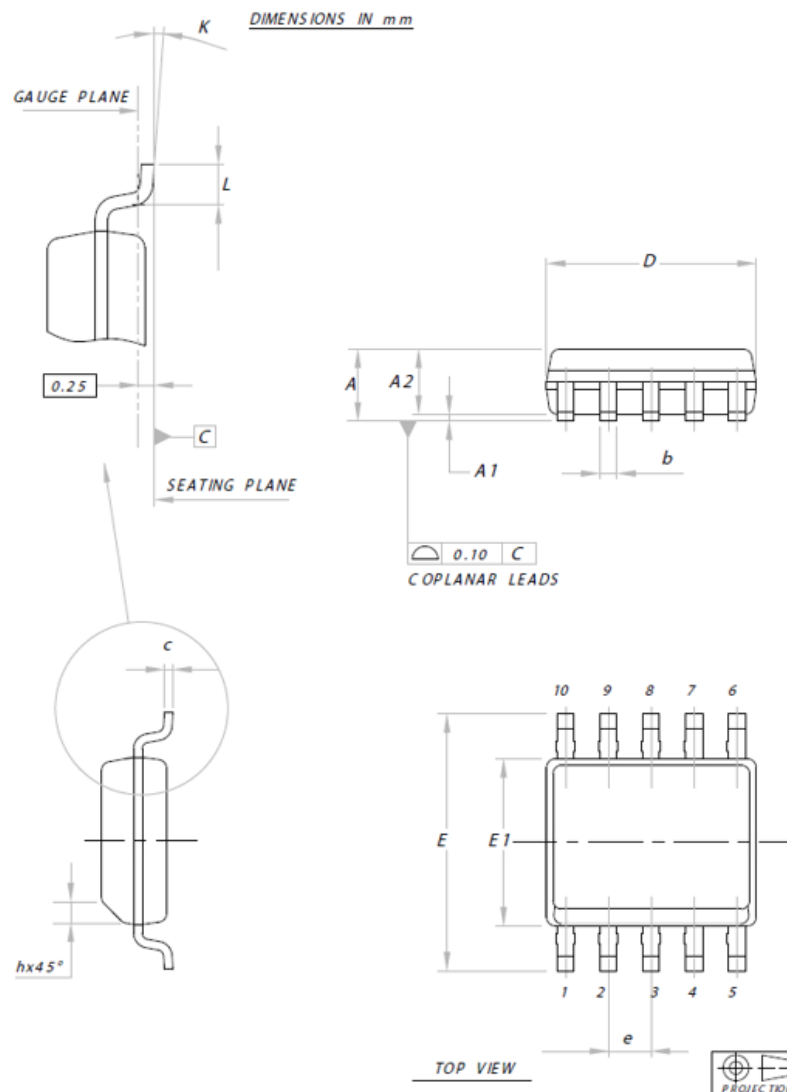


Table 6. SSO10 mechanical data

Dim.	mm		
	Min.	Typ.	Max.
A			1.75
A1	0.10		0.25
A2	1.25		
b	0.31		0.51
c	0.17		0.25
D	4.80	4.90	5
E	5.80	6	6.20
E1	3.80	3.90	4
e		1	
H	0.25		0.50
L	0.40		0.90
K	0°		8°

Figure 16. SSOP10 recommended footprint

DIMENSIONS IN mm

RECOMMENDED FOOTPRINT

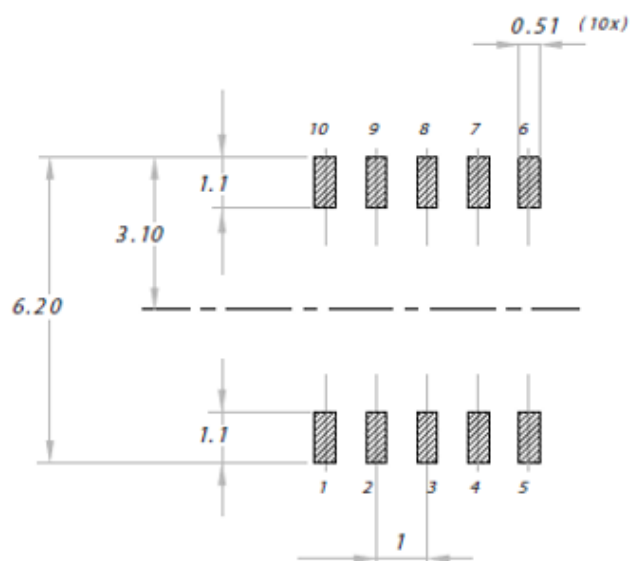


Table 7. Ordering information

Order code	Package	Packaging
VIPER222XSTR	SSOP10	Tape & Reel
VIPER222LSTR	SSOP10	Tape & Reel

## Revision history

**Table 8. Document revision history**

Date	Version	Changes
20-Dec-2019	1	Initial release.
17-Jan-2020	2	Changed min value ILIM parameter in <a href="#">Table 5</a>



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