

Features

- 800 V avalanche rugged power section
- PWM operation with frequency jittering for low EMI
- Operating frequency:
 - 30 kHz for VIPER06Xx
 - 60 kHz for VIPER06Lx
 - 115 kHz for VIPER06Hx
- No need for an auxiliary winding in low-power applications
- Standby power < 30 mW at 265 V_{AC}
- Limiting current with adjustable set point
- On-board soft-start
- Safe auto-restart after a fault condition
- Hysteretic thermal shutdown

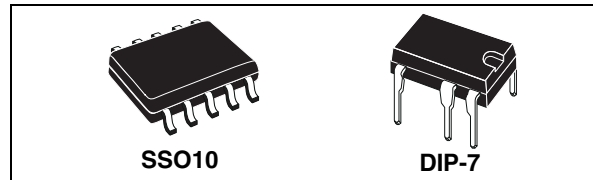
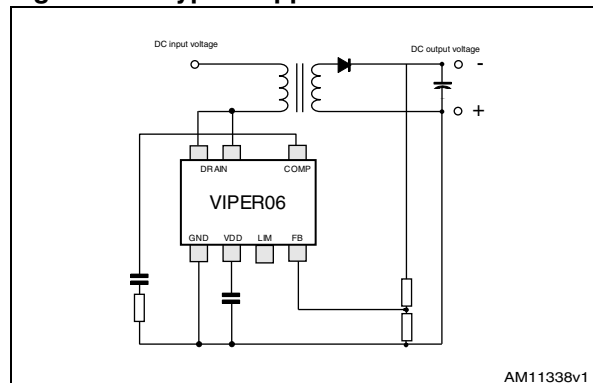


Figure 1. Typical application



Applications

- Replacement of capacitive power supplies
- Home appliances
- Power metering
- LED drivers

Description

The VIPER06 is an offline converter with an 800 V avalanche rugged power section, a PWM controller, a user-defined overcurrent limit, open-loop failure protection, hysteretic thermal protection, soft startup and safe auto-restart after any fault condition. The device is able to power itself directly from the rectified mains, eliminating the need for an auxiliary bias winding. Advanced frequency jittering reduces EMI filter cost. Burst mode operation and the device's very low power consumption both help to meet the standards set by energy-saving regulations.

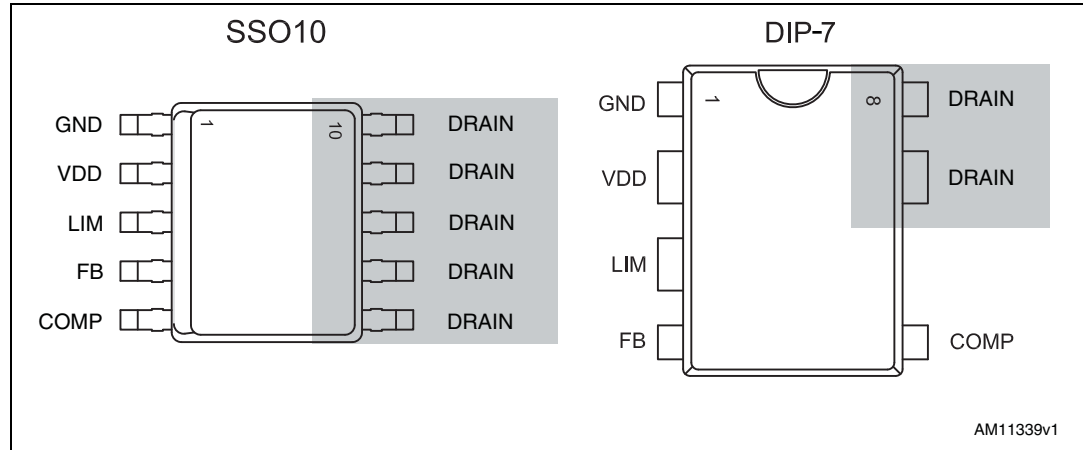
Contents

1	Block diagram	4
2	Typical power	4
3	Pin settings	5
4	Electrical data	6
	4.1 Maximum ratings	6
	4.2 Thermal data	6
	4.3 Electrical characteristics	7
5	Typical electrical characteristics	10
6	Typical circuit	13
7	Power section	15
8	High voltage current generator	15
9	Oscillator	16
10	Soft startup	16
11	Adjustable current limit set point	16
12	FB pin and COMP pin	17
13	Burst mode	18
14	Automatic auto-restart after overload or short-circuit	19
15	Open-loop failure protection	20
16	Package mechanical data	22

17	Order codes	26
18	Revision history	27

3 Pin settings

Figure 3. Connection diagram (top view)



Note: The copper area for heat dissipation has to be designed under the DRAIN pins.

Table 2. Pin description

Pin		Name	Function
DIP-7	SSO10		
1	1	GND	Connected to the source of the internal power MOSFET and controller ground reference.
2	2	VDD	Supply voltage of the control section. This pin provides the charging current of the external capacitor.
3	3	LIM	This pin allows setting the drain current limitation. The limit can be reduced by connecting an external resistor between this pin and GND. Pin left open if default drain current limitation is used.
4	4	FB	Inverting input of the internal transconductance 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 (see V_{FB_REF} in Table 6). An external resistor divider is required for higher output voltages.
5	5	COMP	Output of the internal transconductance 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 pin is used also to directly control the PWM with an optocoupler. The linear voltage range extends from V_{COMPL} to V_{COMPH} (Table 6).
7, 8	6-10	DRAIN	High-voltage drain pins. The built-in high-voltage switched startup bias current is drawn from these pins too. Pins connected to the metal frame to facilitate heat dissipation.

4 Electrical data

4.1 Maximum ratings

Table 3. Absolute maximum ratings

Symbol	Pin (DIP-7)	Parameter	Value		Unit
			Min	Max	
V _{DRAIN}	7, 8	Drain-to-source (ground) voltage		800	V
E _{AV}	7, 8	Repetitive avalanche energy (limited by T _J = 150 °C)		2	mJ
I _{AR}	7, 8	Repetitive avalanche current (limited by T _J = 150 °C)		1	A
I _{DRAIN}	7, 8	Pulse drain current (limited by T _J = 150 °C)		2.5	A
V _{COMP}	5	Input pin voltage	-0.3	3.5	V
V _{FB}	4	Input pin voltage	-0.3	4.8	V
V _{LIM}	3	Input pin voltage	-0.3	2.4	V
V _{DD}	2	Supply voltage	-0.3	Self-limited	V
I _{DD}	2	Input current		20	mA
P _{TOT}		Power dissipation at T _A < 40 °C (DIP-7)		1	W
		Power dissipation at T _A < 50 °C (SSO10)		1	W
T _J		Operating junction temperature range	-40	150	°C
T _{STG}		Storage temperature	-55	150	°C

4.2 Thermal data

Table 4. Thermal data

Symbol	Parameter	Max value SSO10	Max value DIP-7	Unit
R _{thJP}	Thermal resistance junction pin (dissipated power = 1 W)	35	40	°C/W
R _{thJA}	Thermal resistance junction ambient (dissipated power = 1 W)	100	110	°C/W
R _{thJA}	Thermal resistance junction ambient ⁽¹⁾ (dissipated power = 1 W)	80	90	°C/W

1. When mounted on a standard single side FR4 board with 100 mm² (0.155 sq in) of Cu (35 μm thick).

4.3 Electrical characteristics

($T_J = -25$ to 125 °C, $V_{DD} = 14$ V ^(a) unless otherwise specified).

Table 5. Power section

Symbol	Parameter	Test condition	Min	Typ	Max	Unit
V_{BVDSS}	Breakdown voltage	$I_{DRAIN} = 1$ mA, $V_{COMP} = GND$, $T_J = 25$ °C	800			V
I_{OFF}	OFF state drain current	$V_{DRAIN} = \text{max rating}$, $V_{COMP} = GND$			60	μA
$R_{DS(on)}$	Drain-source on-state resistance	$I_{DRAIN} = 0.2$ A, $T_J = 25$ °C			32	Ω
		$I_{DRAIN} = 0.2$ A, $T_J = 125$ °C			67	Ω
C_{OSS}	Effective (energy related) output capacitance	$V_{DRAIN} = 0$ to 640 V		10		pF

Table 6. Supply section

Symbol	Parameter	Test condition	Min	Typ	Max	Unit
Voltage						
V_{DRAIN_START}	Drain-source startup voltage		25		45	V
I_{DDch1}	Startup charging current	$V_{DRAIN} = 100$ V to 640 V, $V_{DD} = 4$ V	-0.6		-1.8	mA
I_{DDch2}	Charging current during operation	$V_{DRAIN} = 100$ V to 640 V, $V_{DD} = 9$ V falling edge	-7		-14	mA
V_{DD}	Operating voltage range		11.5		23.5	V
$V_{DDclamp}$	V_{DD} clamp voltage	$I_{DD} = 15$ mA	23.5			V
V_{DDon}	V_{DD} startup threshold		12	13	14	V
V_{DDCSon}	VDD on internal high-voltage current generator threshold		9.5	10.5	11.5	V
V_{DDoff}	V_{DD} undervoltage shutdown threshold		7	8	9	V
Current						
I_{DD0}	Operating supply current, not switching	$F_{OSC} = 0$ kHz, $V_{COMP} = GND$			0.6	mA
I_{DD1}	Operating supply current, switching	$V_{DRAIN} = 120$ V, $F_{OSC} = 30$ kHz			1.3	mA
		$V_{DRAIN} = 120$ V, $F_{OSC} = 60$ kHz			1.45	mA
		$V_{DRAIN} = 120$ V, $F_{OSC} = 115$ kHz			1.6	mA
I_{DDoff}	Operating supply current with $V_{DD} < V_{DDoff}$	$V_{DD} < V_{DDoff}$			0.35	mA
I_{DDol}	Open-loop failure current threshold	$V_{DD} = V_{DDclamp}$ $V_{COMP} = 3.3$ V,	4			mA

a. Adjust V_{DD} above V_{DDon} startup threshold before setting to 14 V.

Table 7. Controller section

Symbol	Parameter	Test condition	Min	Typ	Max	Unit
Error amplifier						
V_{REF_FB}	FB reference voltage		3.2	3.3	3.4	V
$I_{FB_PULL\ UP}$	Current pull-up			-1		μ A
G_M	Transconductance			2		mA/V
Current setting (LIM) pin						
V_{LIM_LOW}	Low-level clamp voltage	$I_{LIM} = -100 \mu$ A		0.5		V
Compensation (COMP) pin						
V_{COMPH}	Upper saturation limit	$T_J = 25 \text{ }^\circ\text{C}$		3		V
V_{COMPL}	Burst mode threshold	$T_J = 25 \text{ }^\circ\text{C}$	1	1.1	1.2	V
V_{COMPL_HYS}	Burst mode hysteresis	$T_J = 25 \text{ }^\circ\text{C}$		40		mV
H_{COMP}	$\Delta V_{COMP} / \Delta I_{DRAIN}$		4		9	V/A
$R_{COMP(DYN)}$	Dynamic resistance	$V_{FB} = GND$		15		k Ω
I_{COMP}	Source / sink current	$V_{FB} > 100 \text{ mV}$		150		μ A
	Max source current	$V_{COMP} = GND, V_{FB} = GND$		220		μ A
Current limitation						
I_{Dlim}	Drain current limitation	$I_{LIM} = -10 \mu$ A, $V_{COMP} = 3.3 \text{ V}$, $T_J = 25 \text{ }^\circ\text{C}$	0.32	0.35	0.38	A
t_{SS}	Soft-start time			8.5		ms
T_{ON_MIN}	Minimum turn-on time				450	ns
I_{Dlim_bm}	Burst mode current limitation	$V_{COMP} = V_{COMPL}$		85		mA
Overload						
t_{OVL}	Overload time			50		ms
$t_{RESTART}$	Restart time after fault			1		s
Oscillator section						
F_{OSC}	Switching frequency	VIPER06Xx	27	30	33	kHz
		VIPER06Lx	54	60	66	kHz
		VIPER06Hx	103	115	127	kHz
F_D	Modulation depth	$F_{OSC} = 30 \text{ kHz}$		± 3		kHz
		$F_{OSC} = 60 \text{ kHz}$		± 4		kHz
		$F_{OSC} = 115 \text{ kHz}$		± 8		kHz
F_M	Modulation frequency			230		Hz
D_{MAX}	Maximum duty cycle		70		80	%

Table 7. Controller section (continued)

Symbol	Parameter	Test condition	Min	Typ	Max	Unit
Thermal shutdown						
T_{SD}	Thermal shutdown temperature		150	160		°C
T_{HYST}	Thermal shutdown hysteresis			30		°C

5 Typical electrical characteristics

Figure 4. I_{Dim} vs. T_J

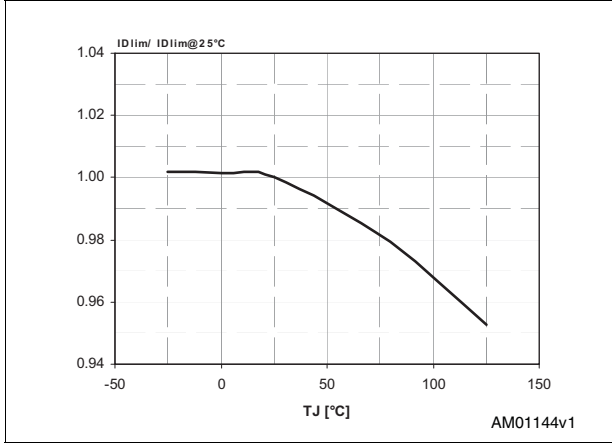


Figure 5. F_{OSC} vs. T_J

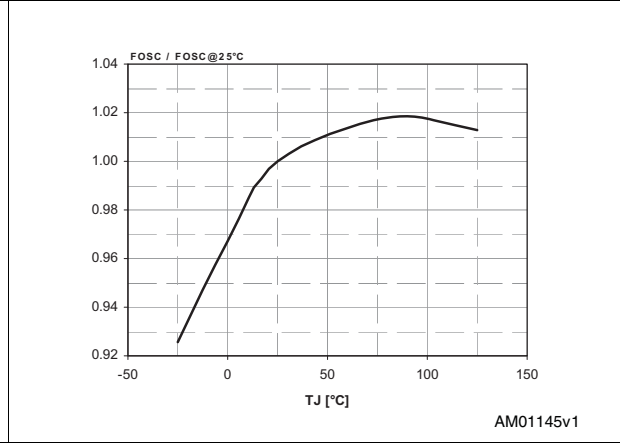


Figure 6. V_{DRAIN_START} vs. T_J

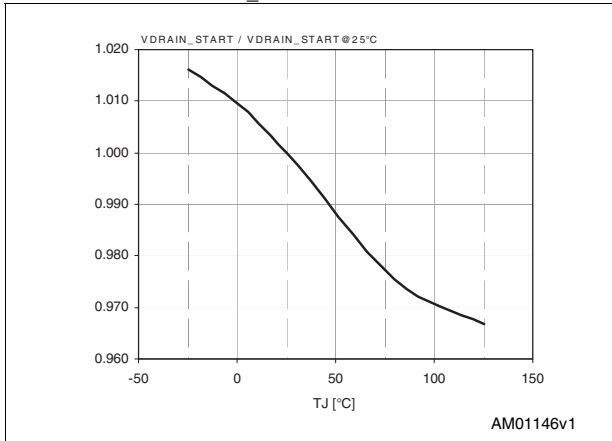


Figure 7. H_{COMP} vs. T_J

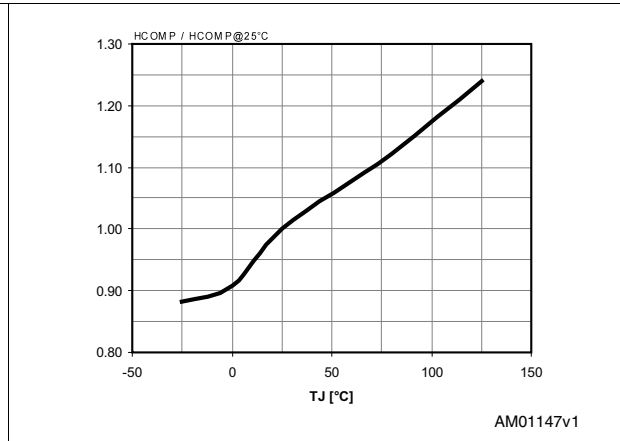


Figure 8. G_M vs. T_J

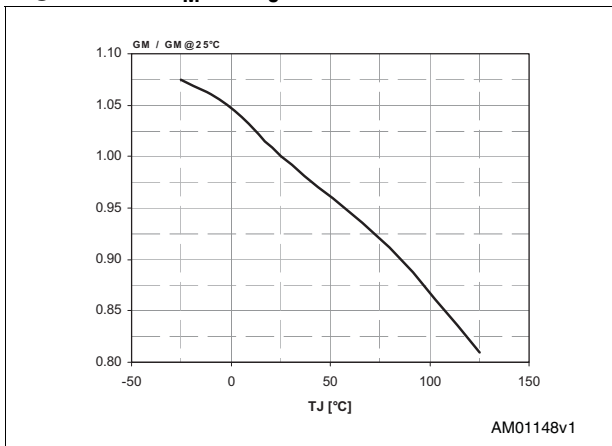


Figure 9. V_{REF_FB} vs. T_J

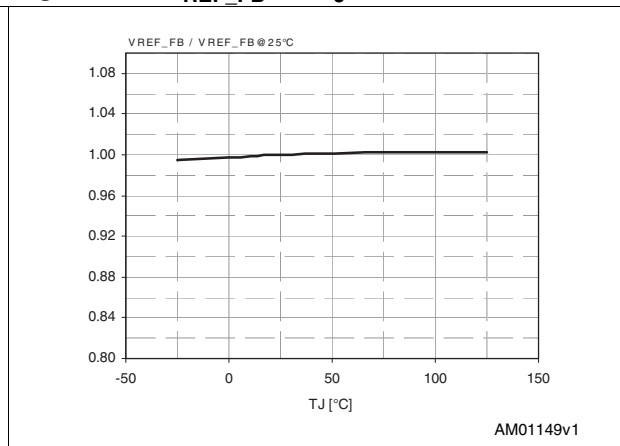


Figure 10. I_{COMP} vs. T_J

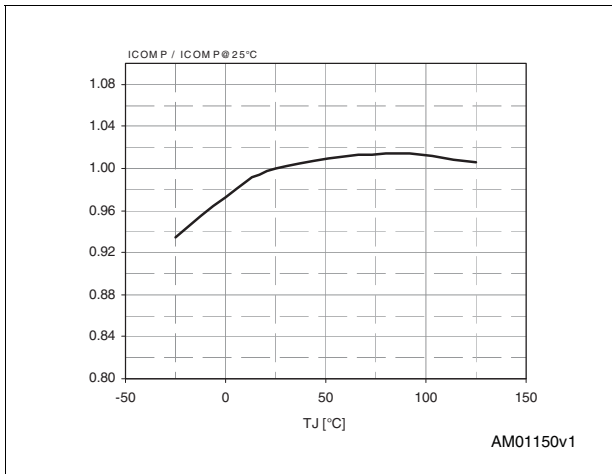


Figure 11. Operating supply current (no switching) vs. T_J

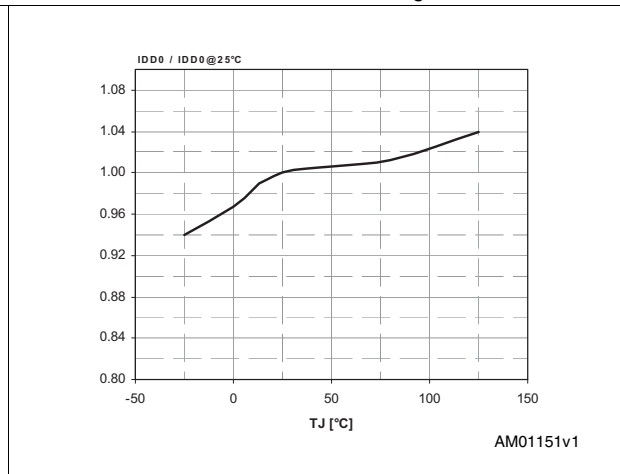


Figure 12. Operating supply current (switching) vs. T_J

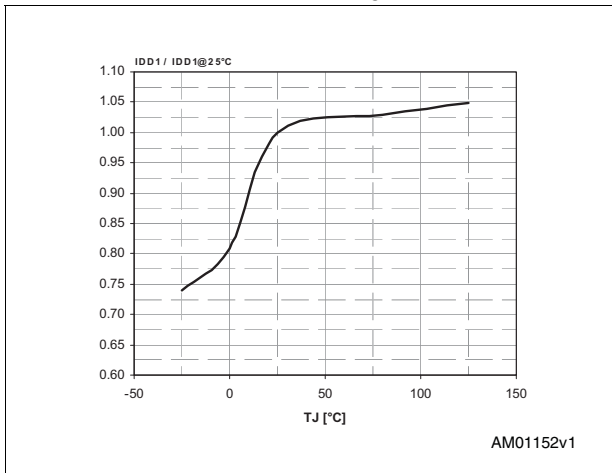


Figure 13. I_{Dlim} vs. R_{LIM}

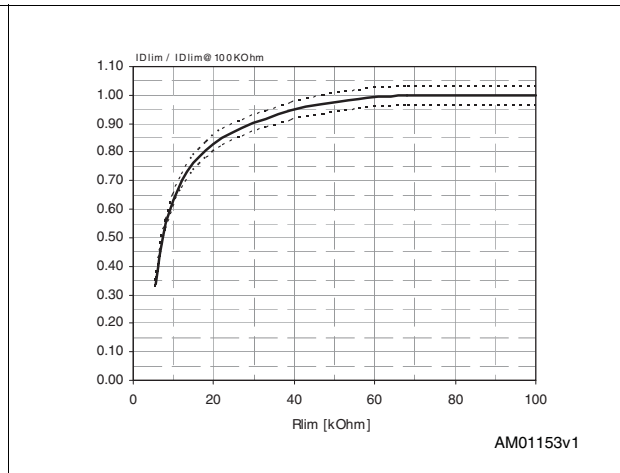


Figure 14. Power MOSFET on-resistance vs. T_J

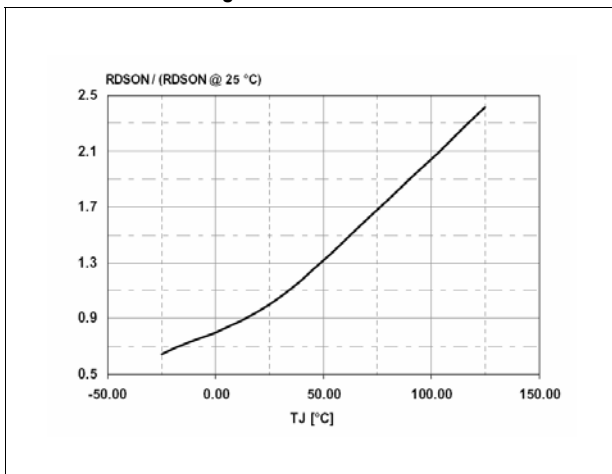


Figure 15. Power MOSFET breakdown voltage vs. T_J

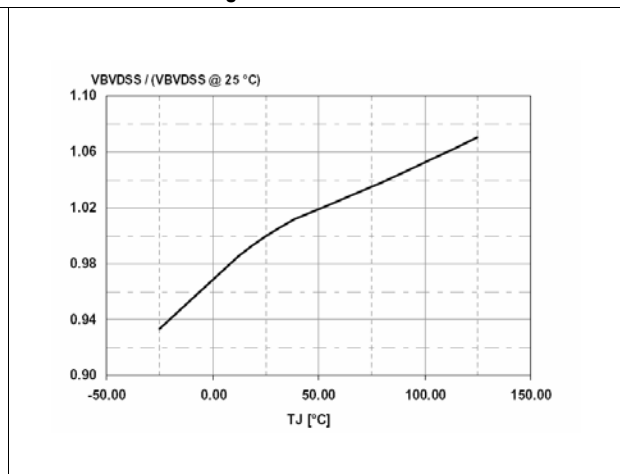
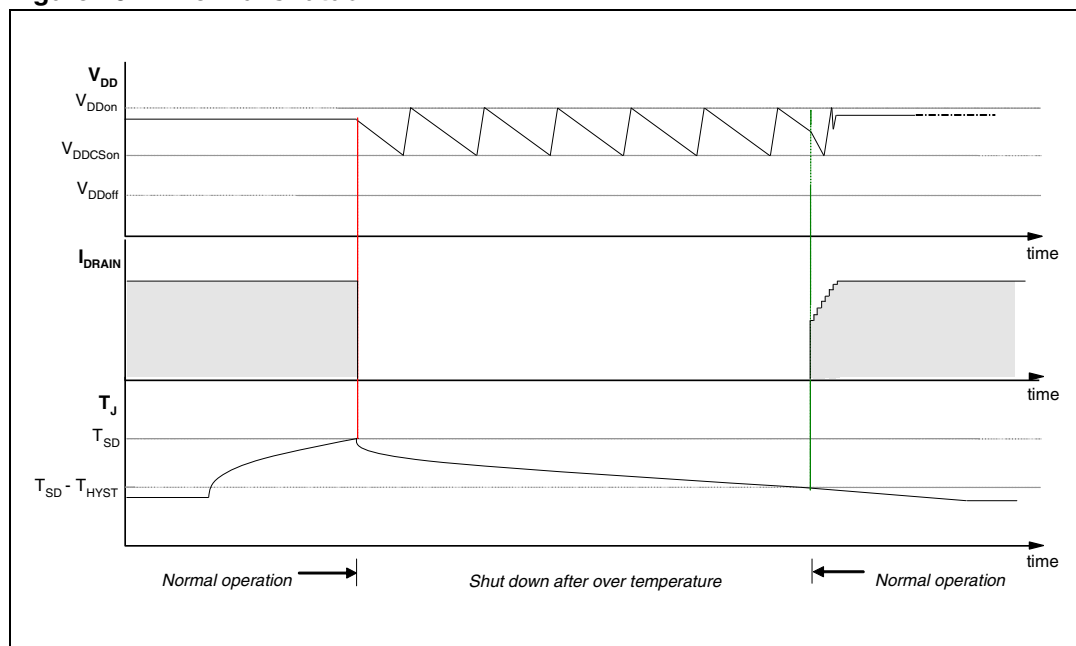


Figure 16. Thermal shutdown



6 Typical circuit

Figure 17. Flyback converter (non-isolated output)

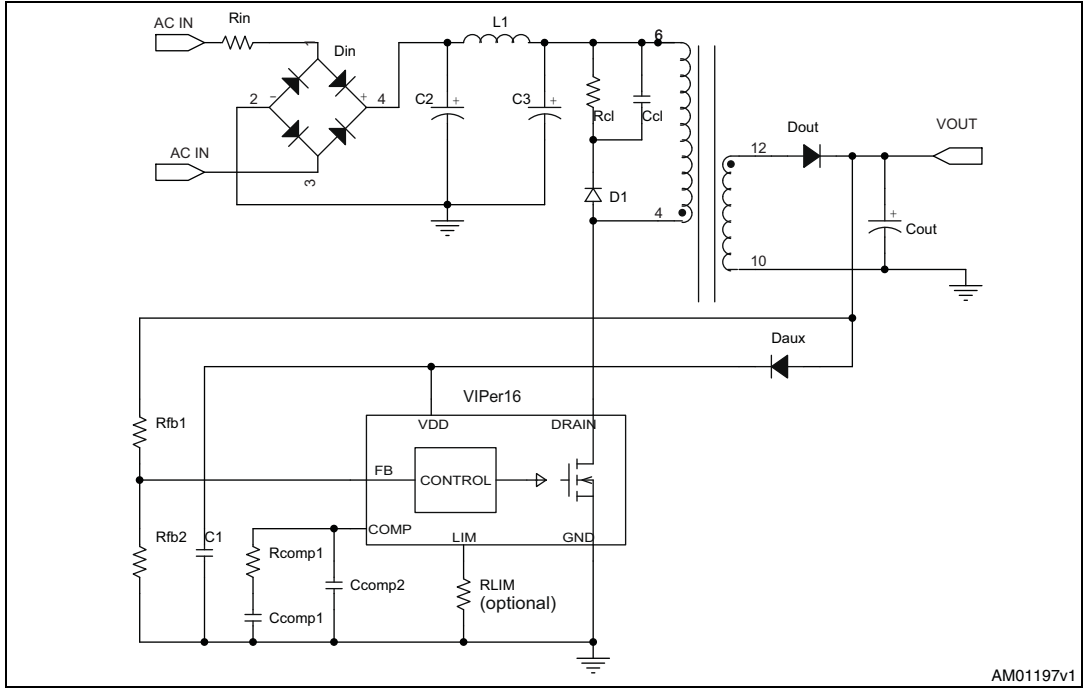


Figure 18. Flyback converter (isolated output)

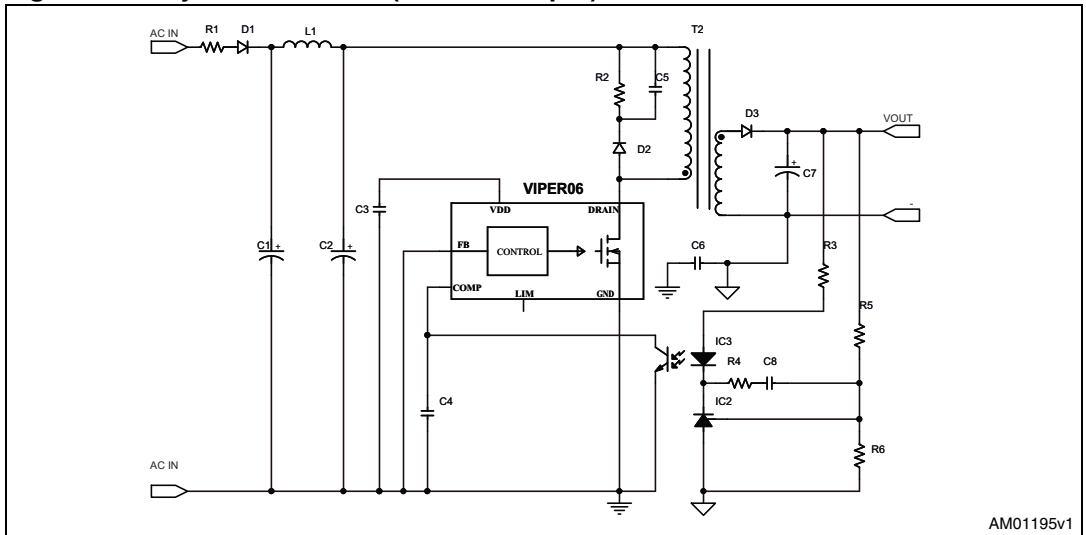
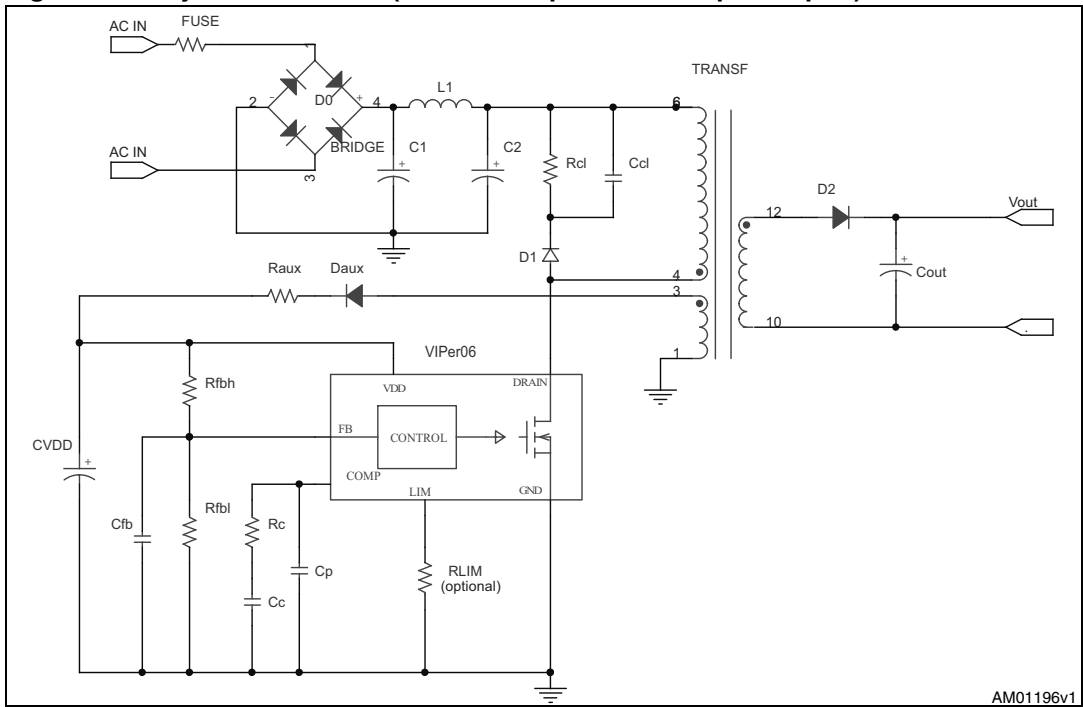
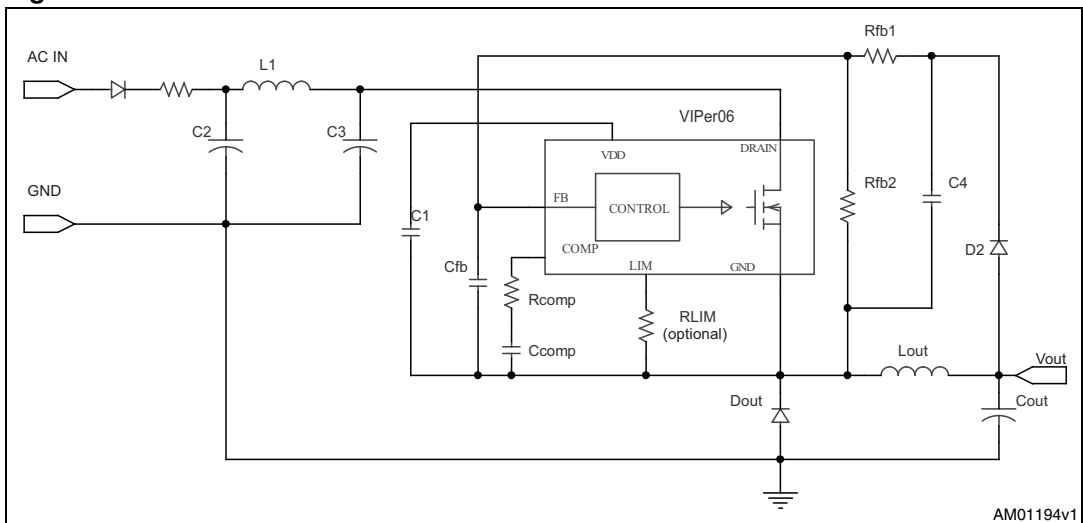


Figure 19. Flyback converter (isolated output without optocoupler)



AM01196v1

Figure 20. Buck converter



AM01194v1

7 Power section

The power section is implemented with an N-channel power MOSFET with a breakdown voltage of 800 V min. and a typical $R_{DS(on)}$ of 32 Ω . It includes a SenseFET structure to allow virtually lossless current sensing and the thermal sensor.

The gate driver of the power MOSFET is designed to supply a controlled gate current during both turn-ON and turn-OFF in order to minimize common-mode EMI. During UVLO conditions, an internal pull-down circuit holds the gate low in order to ensure that the power MOSFET cannot be turned ON accidentally.

8 High voltage current generator

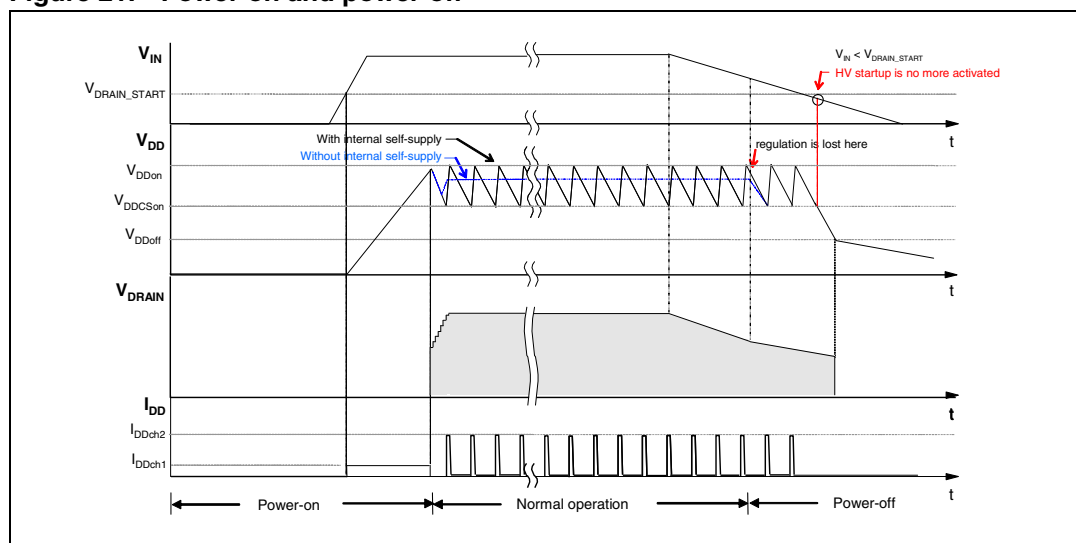
The high-voltage current generator is supplied by the DRAIN pin. At the first startup of the converter it is enabled when the voltage across the input bulk capacitor reaches the V_{DRAIN_START} threshold, sourcing a I_{DDch1} current (see [Table 6 on page 7](#)). As the V_{DD} voltage reaches the V_{DDon} threshold, the power section starts switching and the high-voltage current generator is turned OFF. The VIPER06 is powered by the energy stored in the V_{DD} capacitor.

In a steady-state condition, if the self-biasing function is used, the high-voltage current generator is activated between V_{DDCSon} and V_{DDon} (see [Table 6 on page 7](#)), delivering I_{DDch2} , see [Table 6 on page 7](#) to the V_{DD} capacitor during the MOSFET off-time (see [Figure 21](#)).

The device can also be supplied through the auxiliary winding in which case the high-voltage current source is disabled during steady-state operation, provided that V_{DD} is above V_{DDCSon} .

At converter power-down, the V_{DD} voltage drops and the converter activity stops as it falls below the V_{DDoff} threshold (see [Table 6 on page 7](#)).

Figure 21. Power-on and power-off



9 Oscillator

The switching frequency is internally fixed at 30 kHz or 60 kHz or 115 kHz (respectively part numbers VIPER06Xx, VIPER06Lx and VIPER06Hx).

The switching frequency is modulated by approximately ± 3 kHz (30 kHz version) or ± 4 kHz (60 kHz version) or ± 8 kHz (115 kHz version) at 230 Hz (typical) rate, so that the resulting spread spectrum action distributes the energy of each harmonic of the switching frequency over a number of sideband harmonics having the same energy on the whole, but smaller amplitudes.

10 Soft startup

During the converter's startup phase, the soft-start function progressively increases the cycle-by-cycle drain current limit, up to the default value I_{Dlim} . In this way the drain current is further limited and the output voltage is progressively increased, reducing the stress on the secondary diode. The soft-start time is internally fixed to t_{SS} , see typical value in [Table 7 on page 8](#), and the function is activated for any attempt of converter startup and after a fault event.

This function helps prevent saturation of the transformer during startup and short-circuit.

11 Adjustable current limit set point

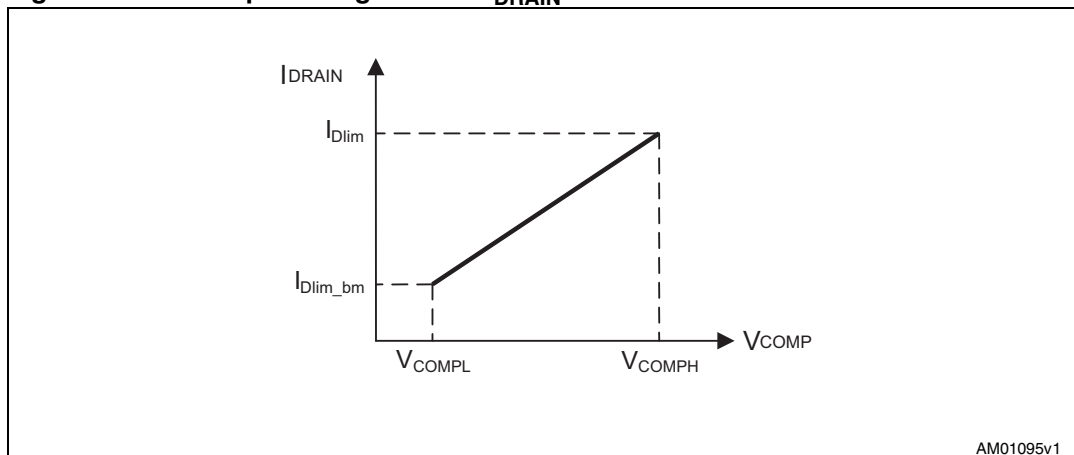
The VIPER06 includes a current-mode PWM controller. The drain current is sensed cycle-by-cycle through the integrated resistor R_{SENSE} and the voltage is applied to the non-inverting input of the PWM comparator, see [Figure 2 on page 4](#). As soon as the sensed voltage is equal to the voltage derived from the COMP pin, the power MOSFET is switched OFF.

In parallel with the PWM operations, the comparator OCP, see [Figure 2 on page 4](#), checks the level of the drain current and switches OFF the power MOSFET in case the current is higher than the threshold I_{Dlim} , see [Table 7 on page 8](#).

The level of the drain current limit I_{Dlim} can be reduced using a resistor R_{LIM} connected between the LIM and GND pins. Current is sunk from the LIM pin through the resistor R_{LIM} and the setup of I_{Dlim} depends on the level of this current. The relation between I_{Dlim} and R_{LIM} is shown in [Figure 13 on page 11](#).

When the LIM pin is left open or if R_{LIM} has a high value (i.e. > 80 k Ω), the current limit is fixed to its default value, I_{Dlim} , as given in [Table 7 on page 8](#).

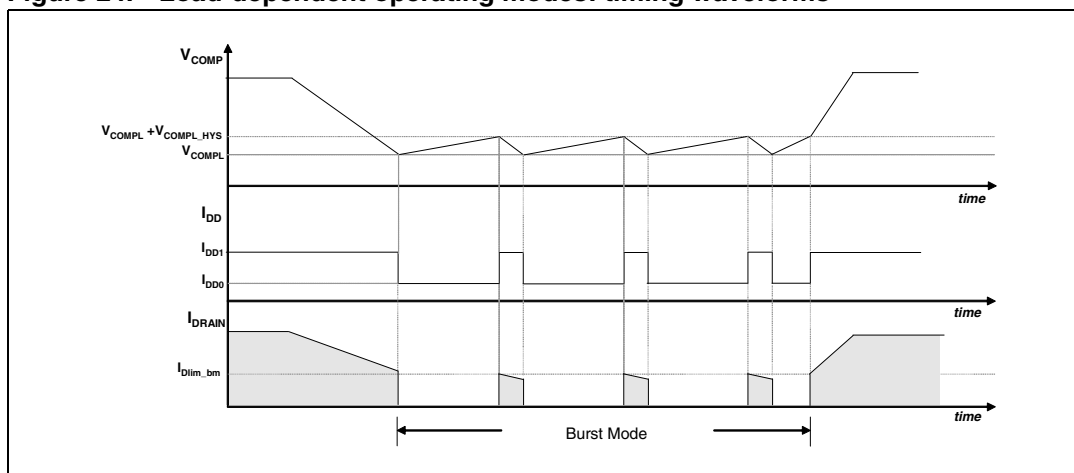
Figure 23. COMP pin voltage versus I_{DRAIN}



13 Burst mode

When the voltage V_{COMP} drops below the threshold, V_{COMPL} , the power MOSFET is kept in the OFF state and the consumption is reduced to the I_{DD0} current, as reported on [Table 6 on page 7](#). In reaction to the loss of energy, the V_{COMP} voltage increases and as soon as it exceeds the threshold $V_{COMPL} + V_{COMPL_HYS}$, the converter starts switching again with a level of consumption equal to the I_{DD1} current. This ON-OFF operation mode, referred to as “burst mode” and shown in [Figure 24 on page 18](#), reduces the average frequency, which can go down even to a few hundreds hertz, thus minimizing all frequency-related losses and making it easier to comply with energy-saving regulations. During burst mode, the drain current limit is reduced to the value I_{Dlim_bm} (given in [Table 7 on page 8](#)) in order to avoid the audible noise issue.

Figure 24. Load-dependent operating modes: timing waveforms



14 Automatic auto-restart after overload or short-circuit

The overload protection is implemented automatically using the integrated up-down counter. Every cycle, it is incremented or decremented depending upon the current logic detection of the limit condition or not. The limit condition is the peak drain current, I_{Dlim} , given in [Table 7 on page 8](#) or the one set by the user through the R_{LIM} resistor, shown in [Figure 13 on page 11](#). After the reset of the counter, if the peak drain current is continuously equal to the level I_{Dlim} , the counter will be incremented until the fixed time, t_{OVL} , at which point the power MOSFET switch ON will be disabled. It will be activated again through the soft-start after the $t_{RESTART}$ time (see [Figure 25](#) and [Figure 26 on page 19](#)) and the time values mentioned in [Table 7 on page 8](#).

For overload or short-circuit events, the power MOSFET switching will be stopped after a period of time dependent upon the counter with a maximum equal to t_{OVL} . The protection sequence continues until the overload condition is removed, see [Figure 25](#) and [Figure 26](#). This protection ensures a low repetition rate of restart attempts of the converter, so that it works safely with extremely low power throughput and avoids overheating the IC in case of repeated overload events. If the overload is removed before the protection tripping, the counter will be decremented cycle-by-cycle down to zero and the IC will not be stopped.

Figure 25. Timing diagram: OLP sequence (IC externally biased)

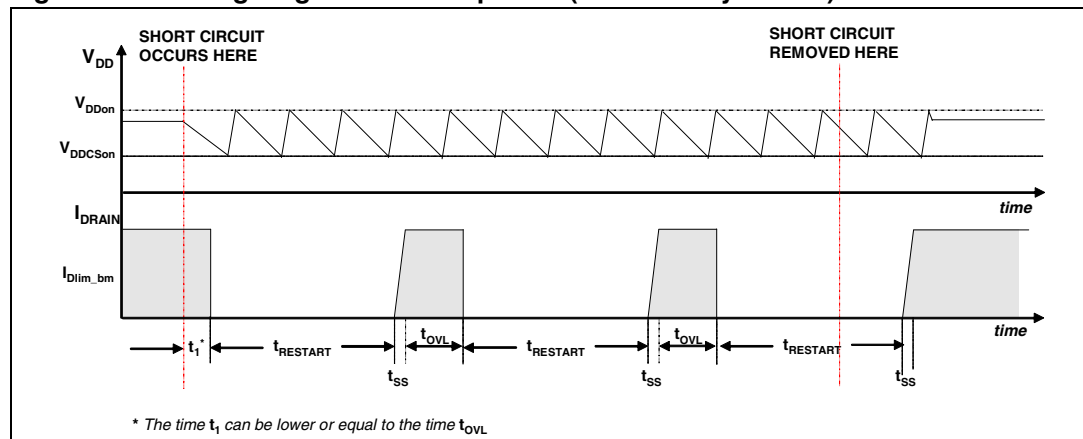
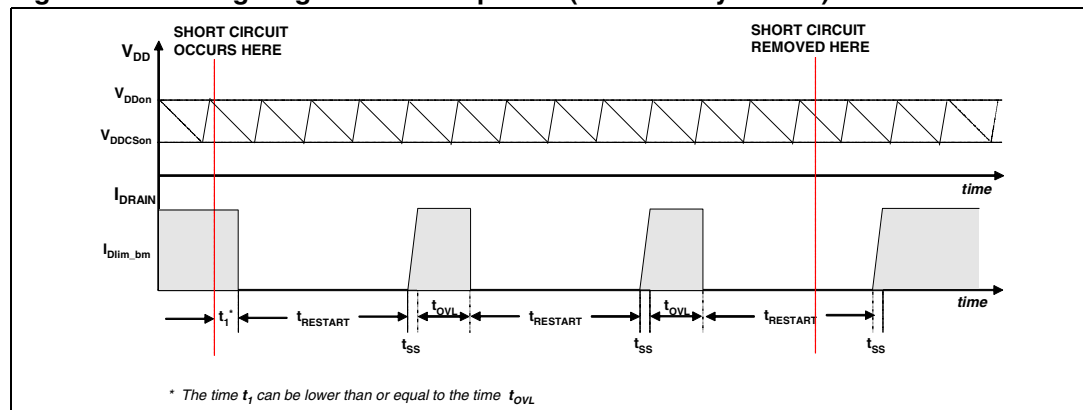


Figure 26. Timing diagram: OLP sequence (IC internally biased)



15 Open-loop failure protection

If the power supply has been designed using flyback topology and the VIPER06 is supplied by an auxiliary winding, as shown in *Figure 27* and *Figure 28 on page 21*, the converter is protected against feedback loop failure or accidental disconnections of the winding.

The following description is applicable for the schematics of *Figure 27* and *Figure 28 on page 21*, respectively the non-isolated flyback and the isolated flyback.

If R_H is open or R_L is shorted, the VIPER06 works at its drain current limitation. The output voltage, V_{OUT} , will increase as does the auxiliary voltage, V_{AUX} , which is coupled with the output through the secondary-to-auxiliary turns ratio.

As the auxiliary voltage increases up to the internal V_{DD} active clamp, $V_{DDclamp}$ (the value is given in *Table 7 on page 8*) and the clamp current injected on the VDD pin exceeds the latch threshold, I_{DDol} (the value is given in *Table 7 on page 8*), a fault signal is internally generated.

In order to distinguish an actual malfunction from a bad auxiliary winding design, both the above conditions (drain current equal to the drain current limitation and current higher than I_{DDol} through the VDD clamp) have to be verified to reveal the fault.

If R_L is open or R_H is shorted, the output voltage, V_{OUT} , will be clamped to the reference voltage V_{REF_FB} (for non-isolated flyback) or to the external TL voltage reference (for isolated flyback).

Figure 27. FB pin connection for non-isolated flyback

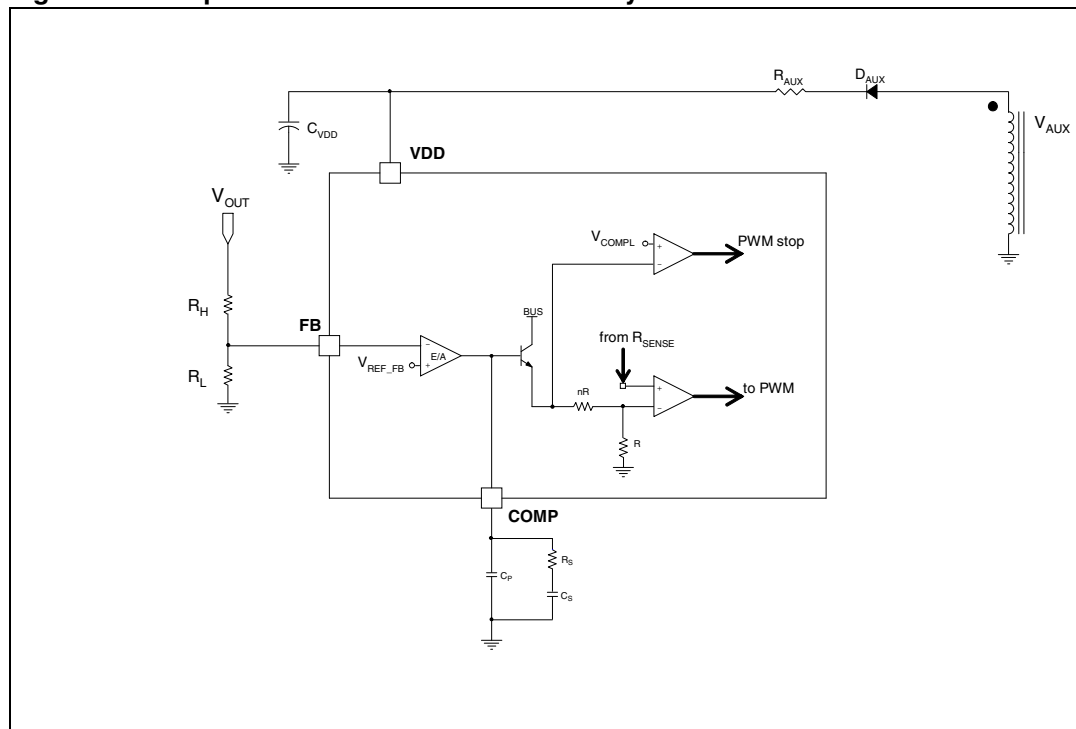
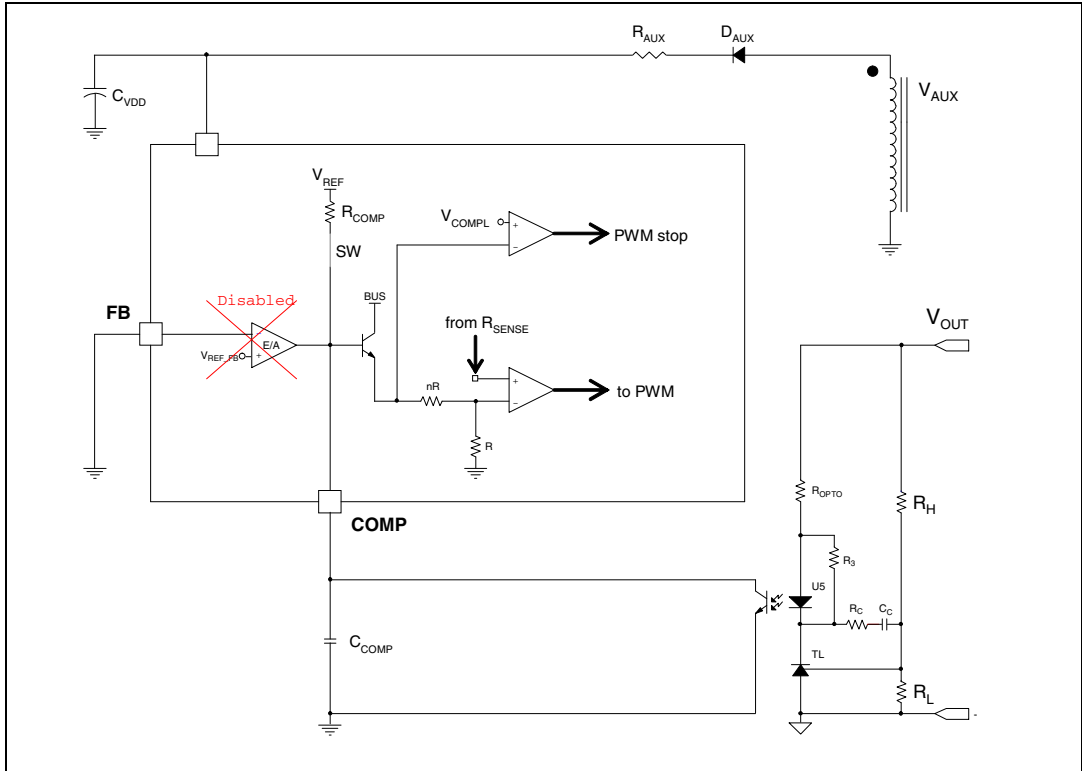


Figure 28. FB pin connection for isolated flyback



16 Package mechanical data

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. ECOPACK® is an ST trademark.

Table 8. DIP-7 mechanical data

Dim.	mm		
	Typ	Min	Max
A			5.33
A1		0.38	
A2	3.30	2.92	4.95
b	0.46	0.36	0.56
b2	1.52	1.14	1.78
c	0.25	0.20	0.36
D	9.27	9.02	10.16
E	7.87	7.62	8.26
E1	6.35	6.10	7.11
e	2.54		
eA	7.62		
eB			10.92
L	3.30	2.92	3.81
M ⁽¹⁾⁽²⁾	2.508		
N	0.50	0.40	0.60
N1			0.60
O ⁽²⁾⁽³⁾	0.548		

1. Creepage distance > 800 V.
2. Creepage distance as given in the 664-1 CEI / IEC standard.
3. Creepage distance 250 V.

- Note:*
- 1 The lead size includes the thickness of the lead finishing material.
 - 2 Dimensions do not include mold protrusion, not to exceed 0.25 mm in total (both sides).
 - 3 Package outline exclusive of metal burr dimensions.
 - 4 Datum plane "H" coincident with the bottom of lead, where lead exits body (refer to [Figure 29 on page 23](#)).

Figure 29. DIP-7 package dimensions

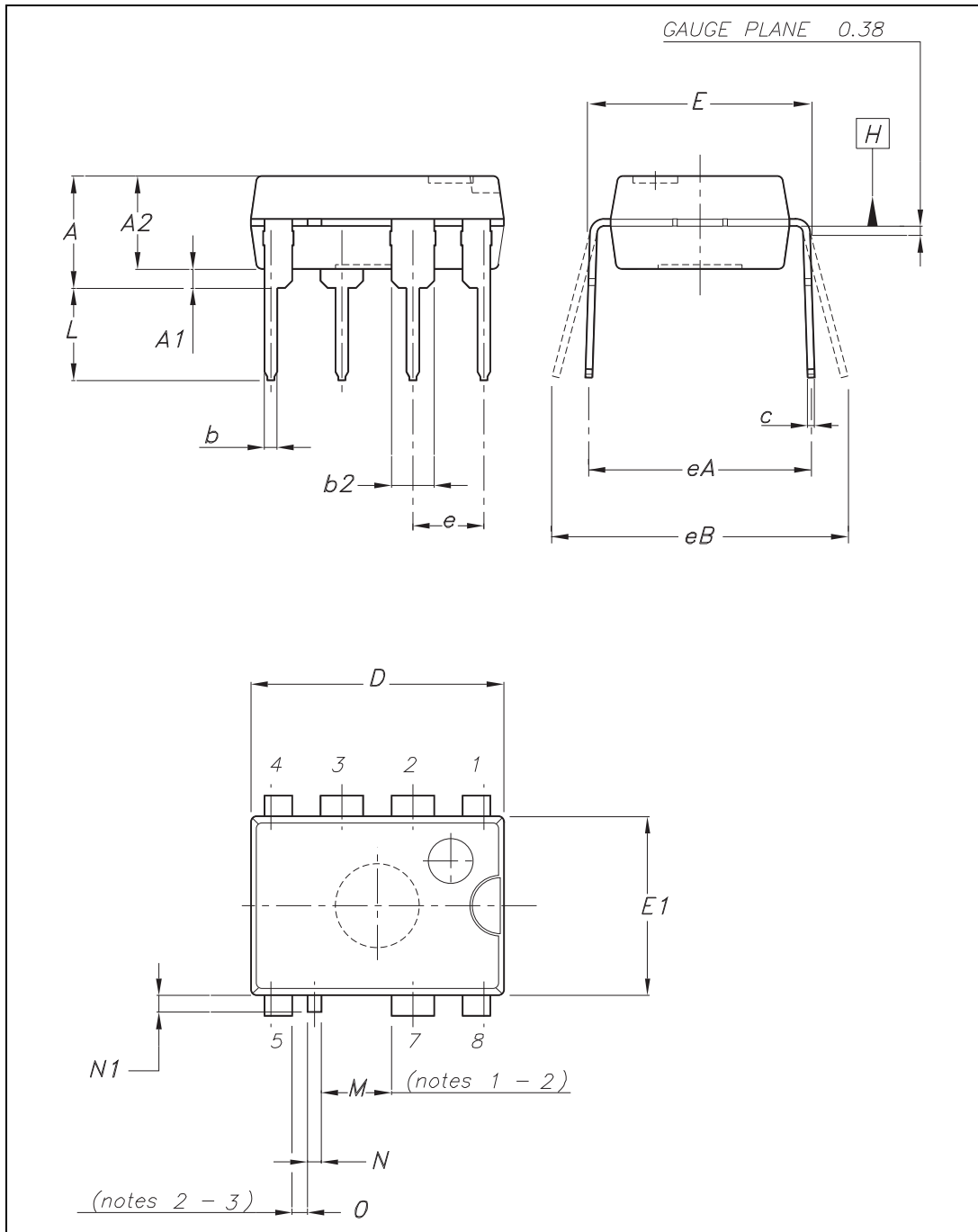
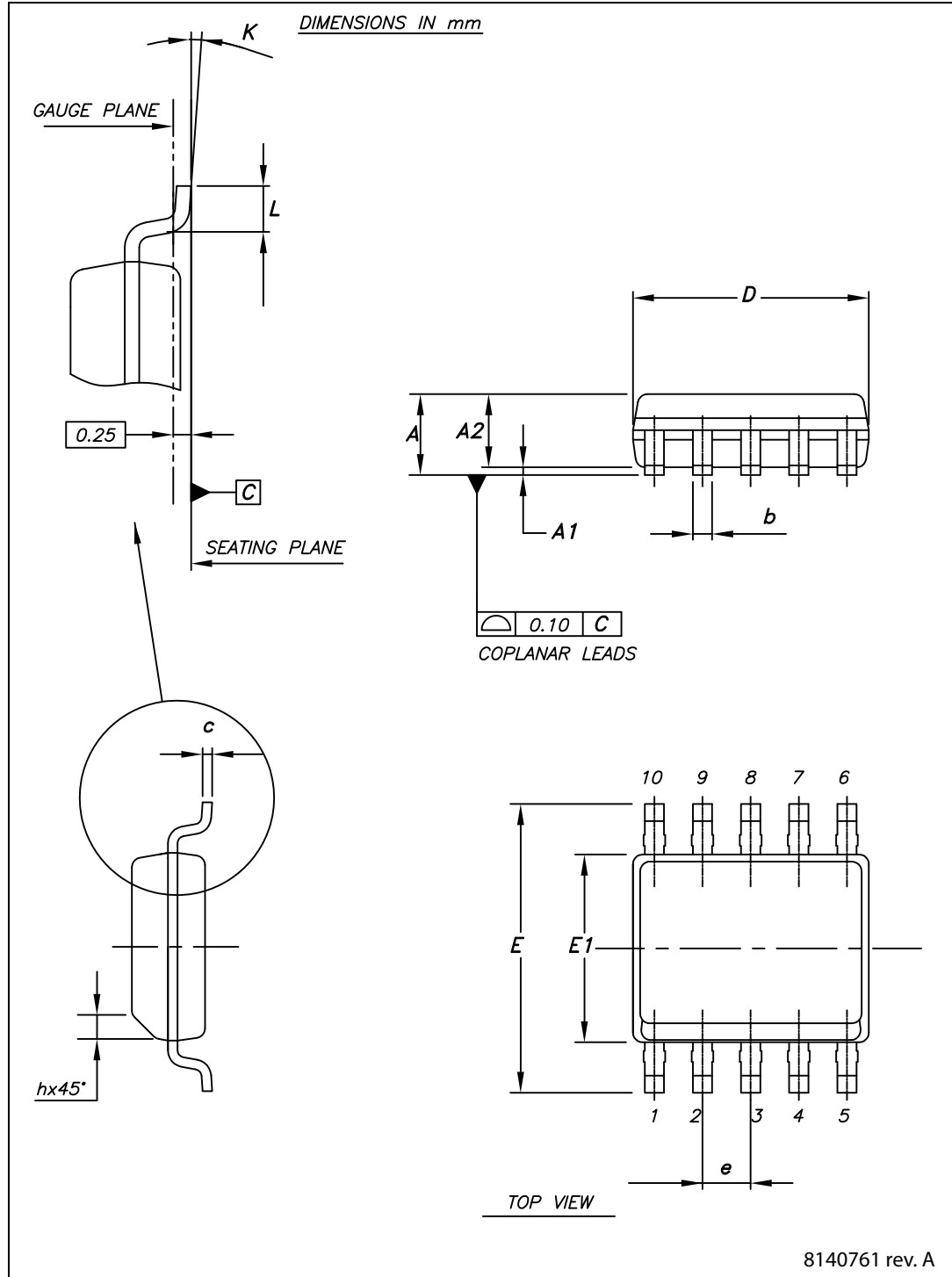


Table 9. SSO10 mechanical data

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

Figure 30. SSO10 package dimensions



17 Order codes

Table 10. Ordering information

Order code	Package	Packaging
VIPER06XN	DIP-7	Tube
VIPER06LN		
VIPER06HN		
VIPER06XS	SSO10	Tube
VIPER06XSTR		Tape and reel
VIPER06LS		Tube
VIPER06LSTR		Tape and reel
VIPER06HS		Tube
VIPER06HSTR		Tape and reel

18 Revision history

Table 11. Document revision history

Date	Revision	Changes
08-Mar-2012	1	Initial release.

Please Read Carefully:

Information in this document is provided solely in connection with ST products. STMicroelectronics NV and its subsidiaries ("ST") reserve the right to make changes, corrections, modifications or improvements, to this document, and the products and services described herein at any time, without notice.

All ST products are sold pursuant to ST's terms and conditions of sale.

Purchasers are solely responsible for the choice, selection and use of the ST products and services described herein, and ST assumes no liability whatsoever relating to the choice, selection or use of the ST products and services described herein.

No license, express or implied, by estoppel or otherwise, to any intellectual property rights is granted under this document. If any part of this document refers to any third party products or services it shall not be deemed a license grant by ST for the use of such third party products or services, or any intellectual property contained therein or considered as a warranty covering the use in any manner whatsoever of such third party products or services or any intellectual property contained therein.

UNLESS OTHERWISE SET FORTH IN ST'S TERMS AND CONDITIONS OF SALE ST DISCLAIMS ANY EXPRESS OR IMPLIED WARRANTY WITH RESPECT TO THE USE AND/OR SALE OF ST PRODUCTS INCLUDING WITHOUT LIMITATION IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE (AND THEIR EQUIVALENTS UNDER THE LAWS OF ANY JURISDICTION), OR INFRINGEMENT OF ANY PATENT, COPYRIGHT OR OTHER INTELLECTUAL PROPERTY RIGHT.

UNLESS EXPRESSLY APPROVED IN WRITING BY TWO AUTHORIZED ST REPRESENTATIVES, ST PRODUCTS ARE NOT RECOMMENDED, AUTHORIZED OR WARRANTED FOR USE IN MILITARY, AIR CRAFT, SPACE, LIFE SAVING, OR LIFE SUSTAINING APPLICATIONS, NOR IN PRODUCTS OR SYSTEMS WHERE FAILURE OR MALFUNCTION MAY RESULT IN PERSONAL INJURY, DEATH, OR SEVERE PROPERTY OR ENVIRONMENTAL DAMAGE. ST PRODUCTS WHICH ARE NOT SPECIFIED AS "AUTOMOTIVE GRADE" MAY ONLY BE USED IN AUTOMOTIVE APPLICATIONS AT USER'S OWN RISK.

Resale of ST products with provisions different from the statements and/or technical features set forth in this document shall immediately void any warranty granted by ST for the ST product or service described herein and shall not create or extend in any manner whatsoever, any liability of ST.

ST and the ST logo are trademarks or registered trademarks of ST in various countries.

Information in this document supersedes and replaces all information previously supplied.

The ST logo is a registered trademark of STMicroelectronics. All other names are the property of their respective owners.

© 2012 STMicroelectronics - All rights reserved

STMicroelectronics group of companies

Australia - Belgium - Brazil - Canada - China - Czech Republic - Finland - France - Germany - Hong Kong - India - Israel - Italy - Japan - Malaysia - Malta - Morocco - Philippines - Singapore - Spain - Sweden - Switzerland - United Kingdom - United States of America

www.st.com