VIPER06

Fixed-frequency VIPer™ plus family

Datasheet — production data

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

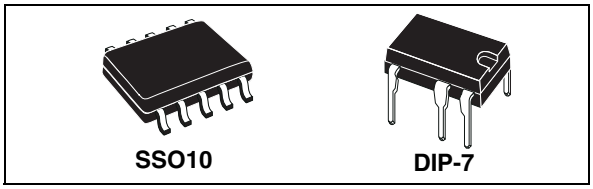
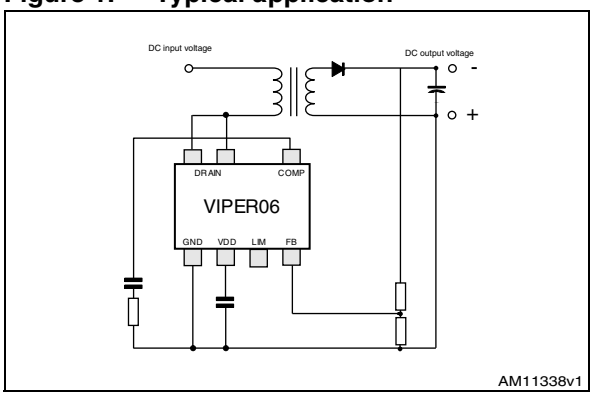


Figure 1. Typical application



Applications

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

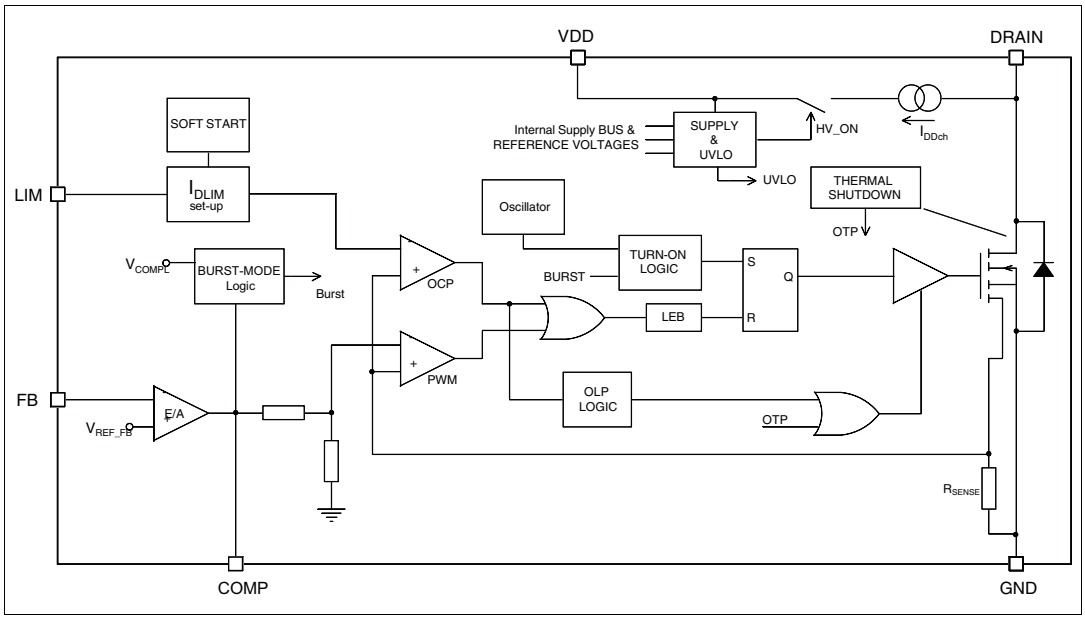
Description

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

Figure 2. Block diagram



2 Typical power

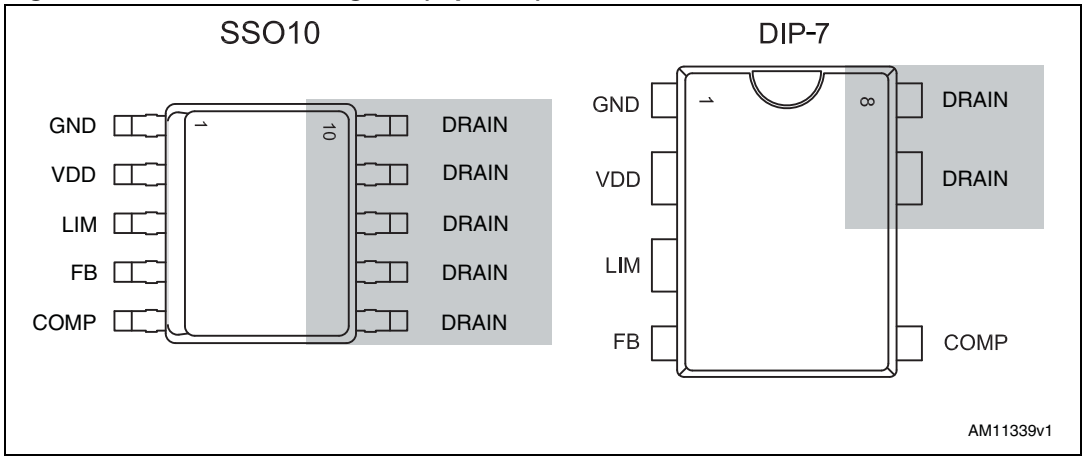
Table 1. Typical power

Part number	230 V_{AC}		85-265 V_{AC}	
	Adapter(1)	Open frame(2)	Adapter(1)	Open frame(2)
VIPER06	6 W	8 W	4 W	5 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 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 mm^2 (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} = 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		µA
G_M	Transconductance			2		mA/V
Current setting (LIM) pin						
V_{LIM_LOW}	Low-level clamp voltage	I_{LIM} = -100 µA		0.5		V
Compensation (COMP) pin						
V_{COMPH}	Upper saturation limit	T_J = 25 °C		3		V
V_{COMPL}	Burst mode threshold	T_J = 25 °C	1	1.1	1.2	V
V_{COMPL_HYS}	Burst mode hysteresis	T_J = 25 °C		40		mV
H_{COMP}	ΔV_{COMP} / ΔI_{DRAIN}		4		9	V/A
$R_{COMP(DYN)}$	Dynamic resistance	V_{FB} = GND		15		kΩ
I_{COMP}	Source / sink current	V_{FB} > 100 mV		150		µA
	Max source current	V_{COMP} = GND, V_{FB} = GND		220		µA
Current limitation						
I_{Dlim}	Drain current limitation	I_{LIM} = -10 µA, V_{COMP} = 3.3 V, T_J = 25 °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 kHz		±3		kHz
		F_{OSC} = 60 kHz		±4		kHz
		F_{OSC} = 115 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_{Dlim} vs. T_J

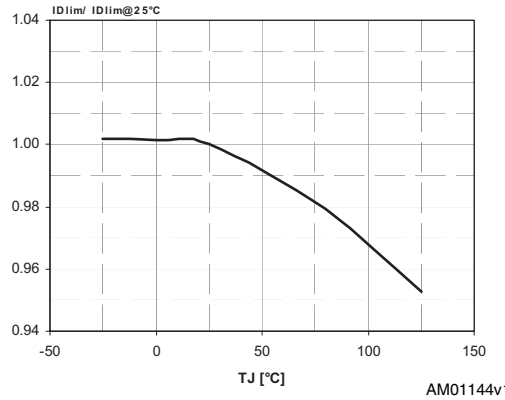


Figure 5. F_{OSC} vs. T_J

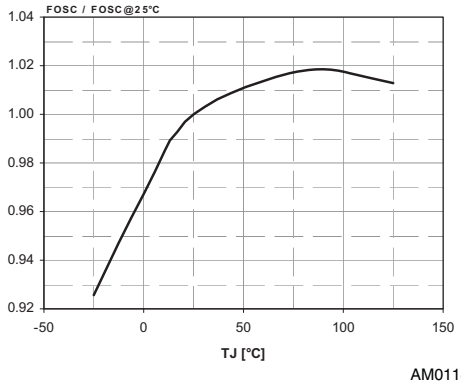


Figure 6. V_{DRAIN_START} vs. T_J

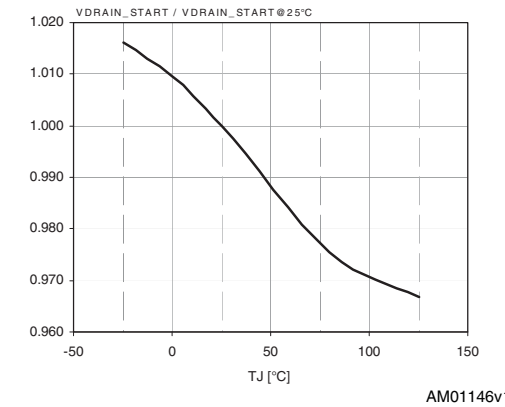


Figure 7. H_{COMP} vs. T_J

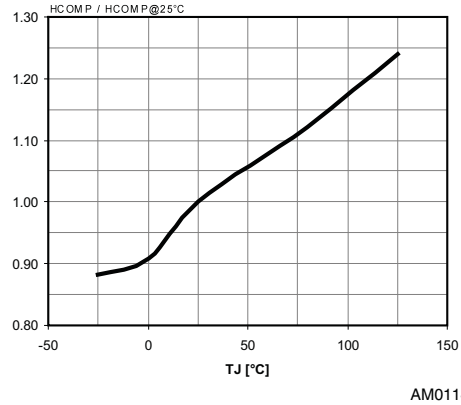


Figure 8. G_M vs. T_J

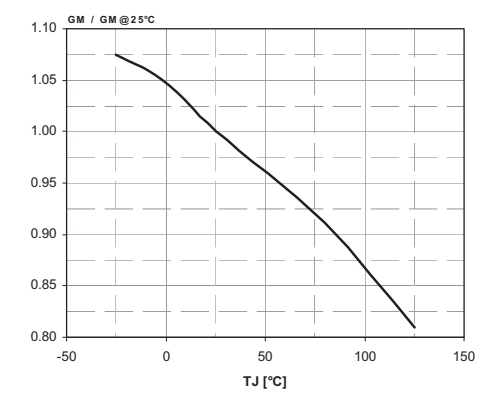


Figure 9. V_{REF_FB} vs. T_J

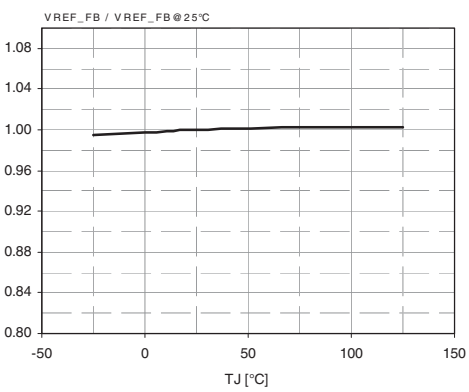


Figure 10. I_{COMP} vs. T_J

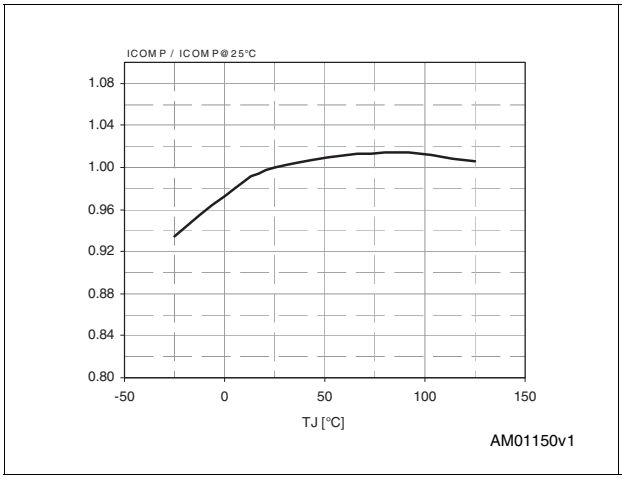


Figure 11. Operating supply current (no switching) vs. T_J

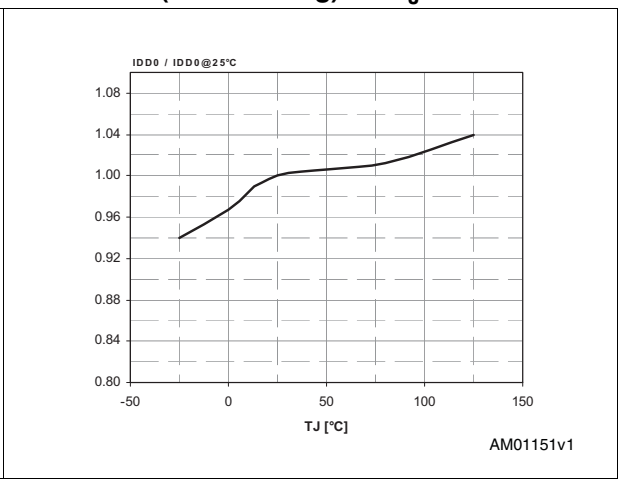


Figure 12. Operating supply current (switching) vs. T_J

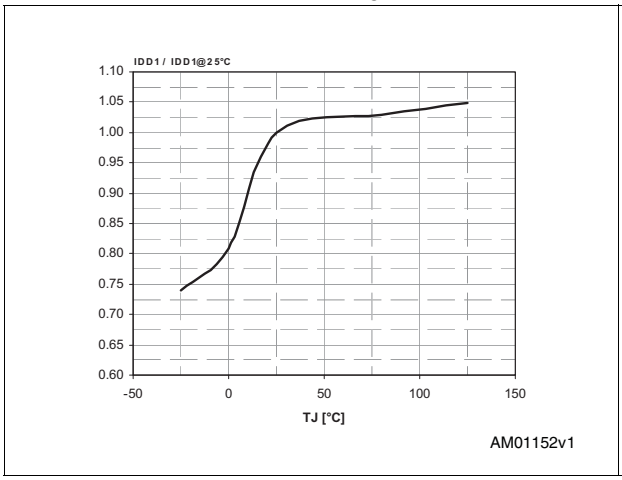


Figure 13. I_{Dlim} vs. R_{LIM}

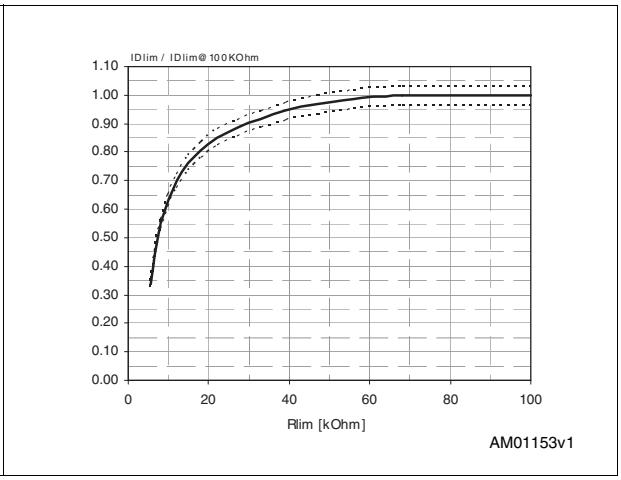


Figure 14. Power MOSFET on-resistance vs. T_J

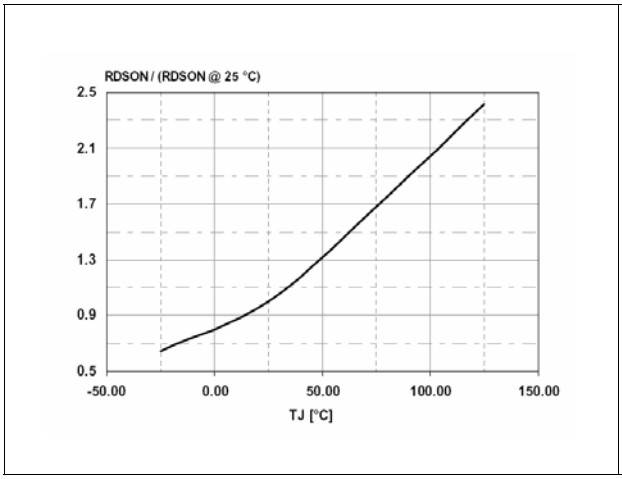


Figure 15. Power MOSFET breakdown voltage vs. T_J

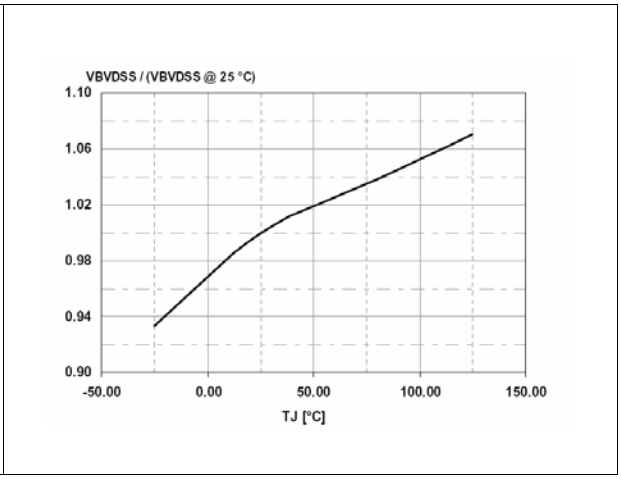
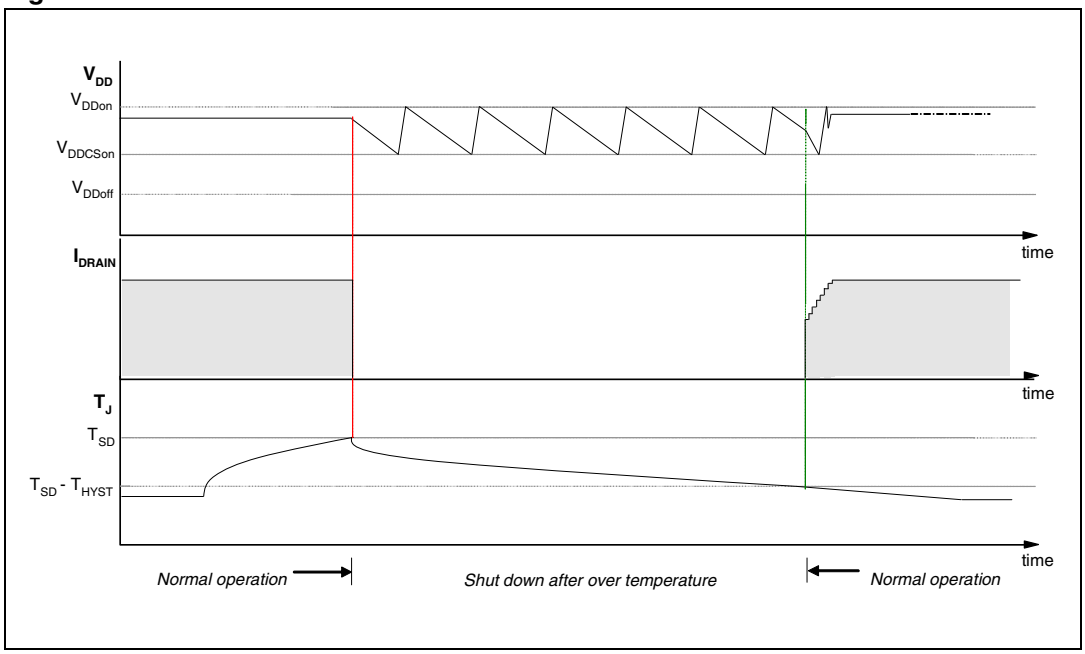


Figure 16. Thermal shutdown



6 Typical circuit

Figure 17. Flyback converter (non-isolated output)

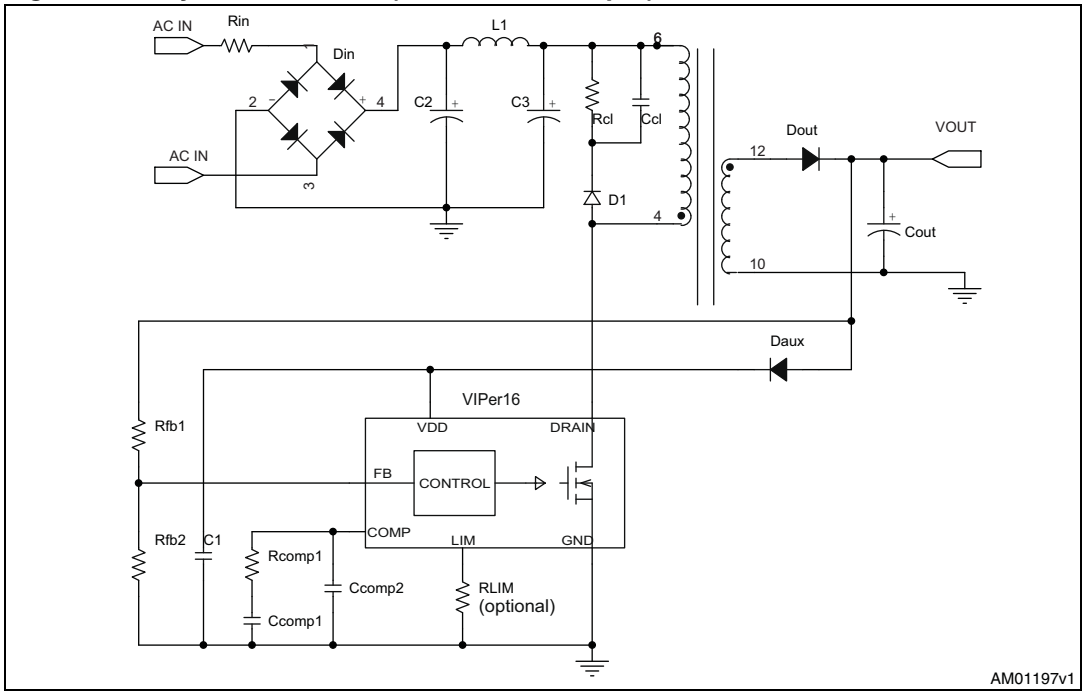


Figure 18. Flyback converter (isolated output)

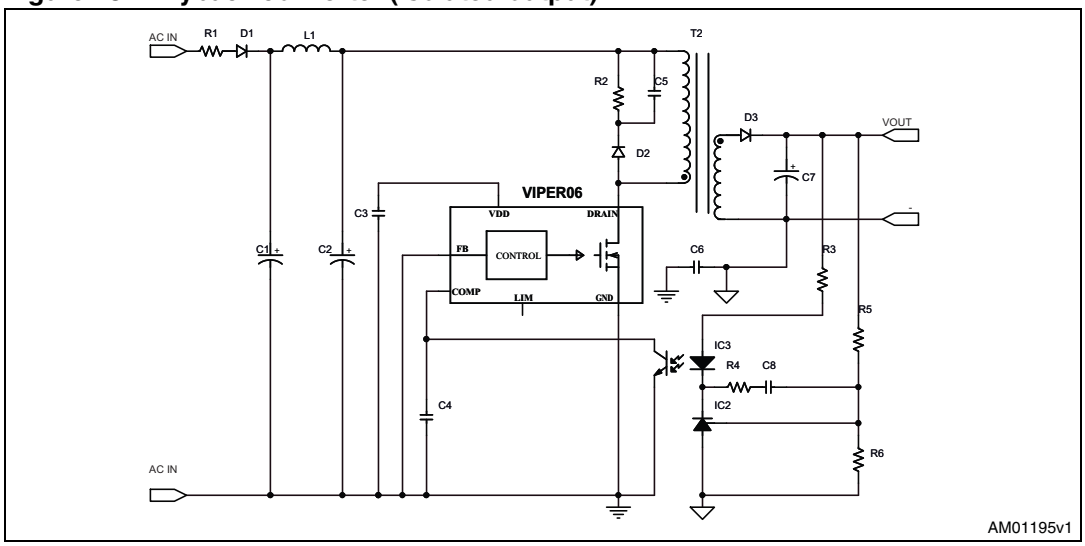


Figure 19. Flyback converter (isolated output without optocoupler)

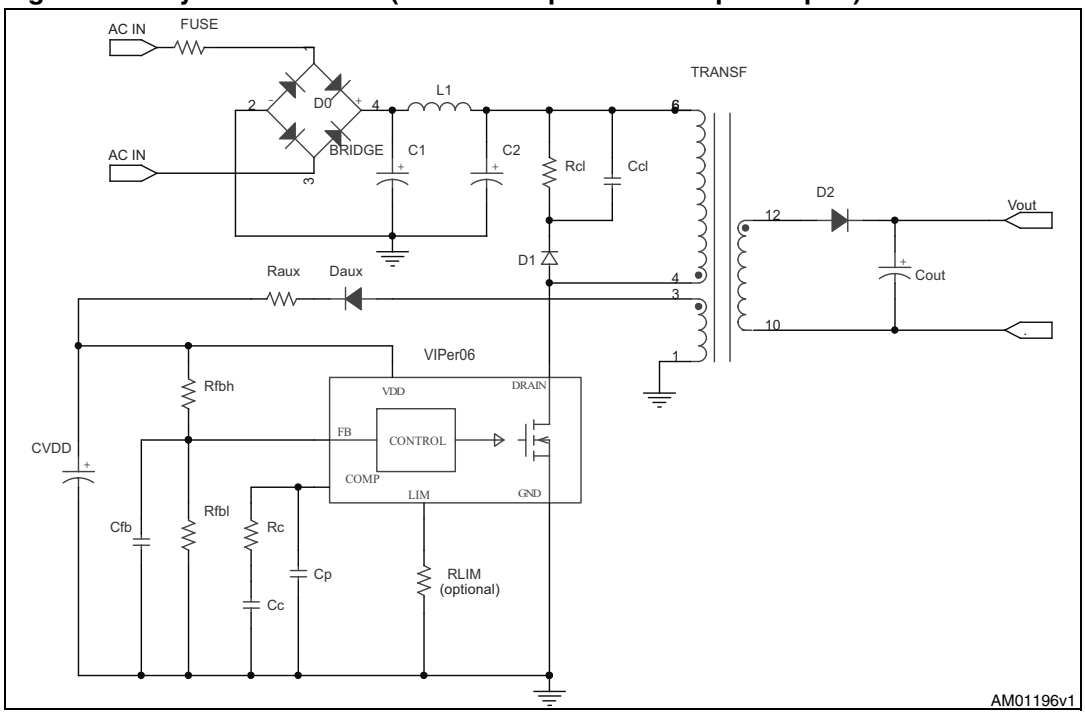
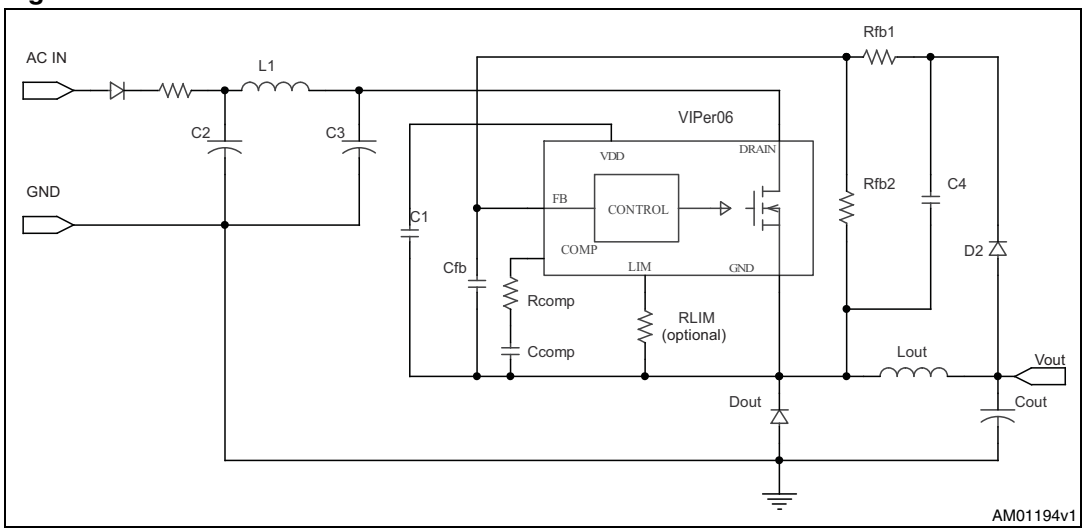


Figure 20. Buck converter



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

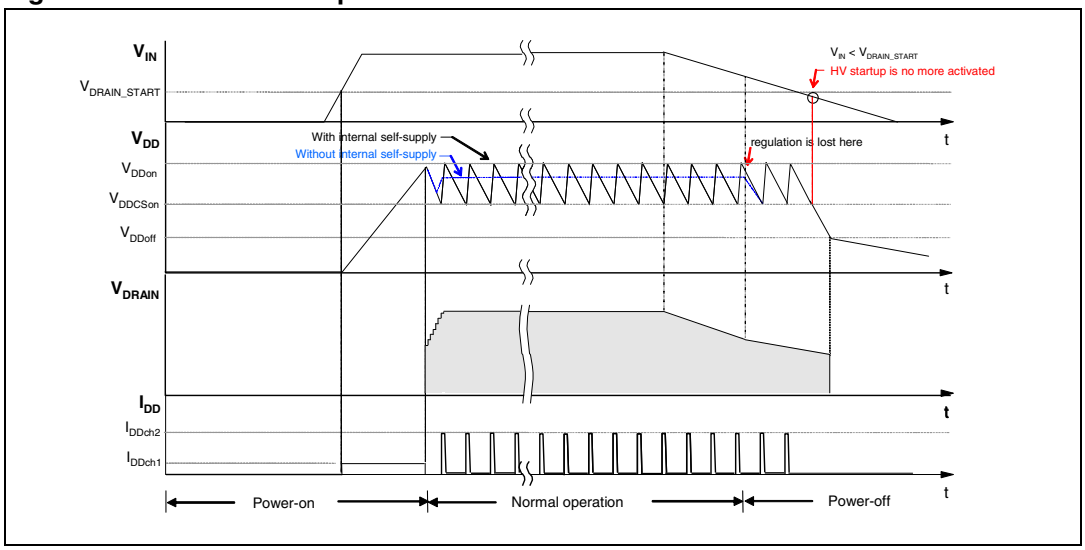
The high-voltage current generator is supplied by the DRAIN pin. At the first startup of the converter it is enabled when the voltage across the input bulk capacitor reaches the V_{DRAIN_START} threshold, sourcing a I_{DDch1} current (see *Table 6 on page 7*). As the V_{DD} voltage reaches the V_{DDon} 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 VDD 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 kΩ), the current limit is fixed to its default value, I_{Dlim}, as given in *Table 7 on page 8*.

12 FB pin and COMP pin

The device can be used both in non-isolated and isolated topology. In non-isolated topology, the feedback signal from the output voltage is applied directly to the FB pin as the inverting input of the internal error amplifier having the reference voltage, $V_{REF\_FB,}$ see *Table 7 on page 8*.

The output of the error amplifier sources and sinks the current, $I_{COMP,}$ respectively to and from the compensation network connected on the COMP pin. This signal is then compared in the PWM comparator with the signal coming from the SenseFET in order to switch off the power MOSFET on a cycle-by-cycle basis. See the *Figure 2 on page 4* and the *Figure 22*.

When the power supply output voltage is equal to the error amplifier reference voltage, V_{REF_FB}, a single resistor has to be connected from the output to the FB pin. For higher output voltages the external resistor divider is needed. If the voltage on the FB pin is accidentally left floating, an internal pull-up protects the controller.

The output of the error amplifier is externally accessible through the COMP pin and it's used for the loop compensation, usually an RC network.

As shown in *Figure 22*, in case of an isolated power supply, the internal error amplifier has to be disabled (FB pin shorted to GND). In this case an internal resistor is connected between an internal reference voltage and the COMP pin, see *Figure 22*. The current loop has to be closed on the COMP pin through the opto-transistor in parallel with the compensation network. The V_{COMP} dynamic range is between V_{COMPL} and V_{COMPH} shown in *Figure 23 on page 18*.

When the voltage V_{COMP} drops below the voltage threshold V_{COMPL}, the converter enters burst mode, see *Section 13 on page 18*.

When the voltage V_{COMP} rises above the V_{COMPH} threshold, the peak drain current, as well as the deliverable output power, will reach its limit.

Figure 22. Feedback circuit

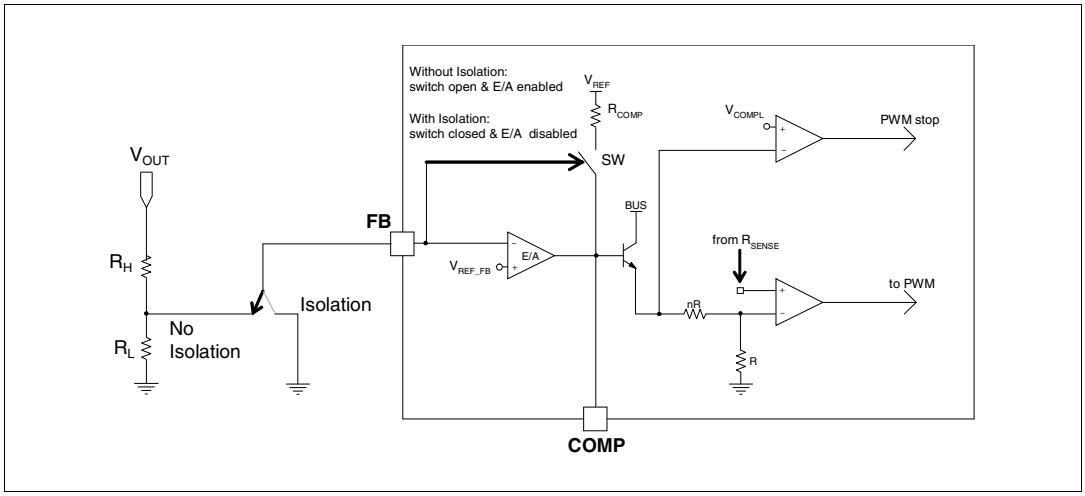
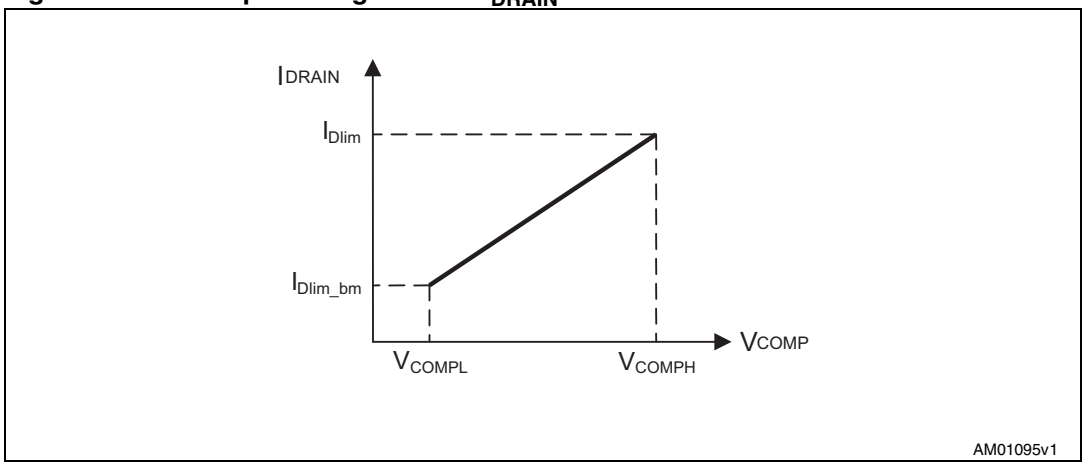


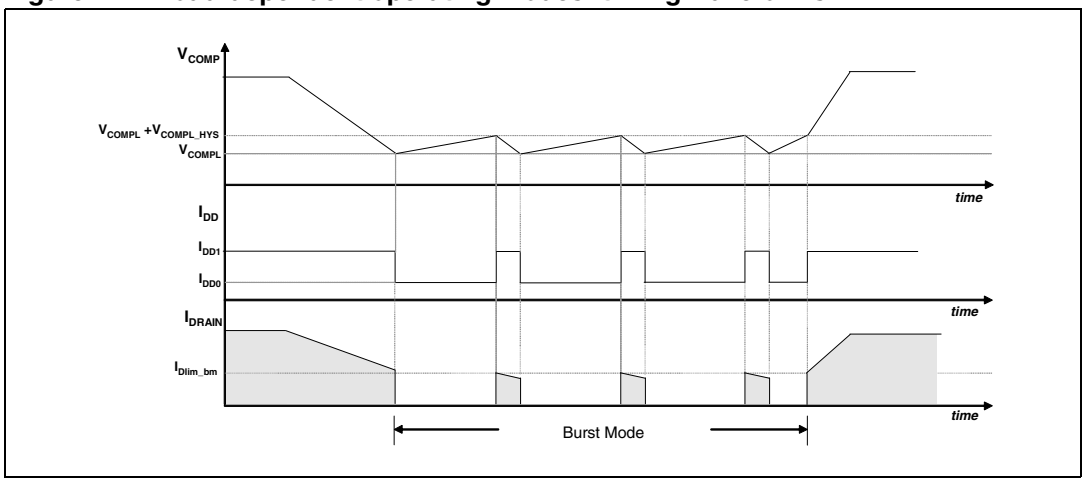
Figure 23. COMP pin voltage versus I_{DRAIN}



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)

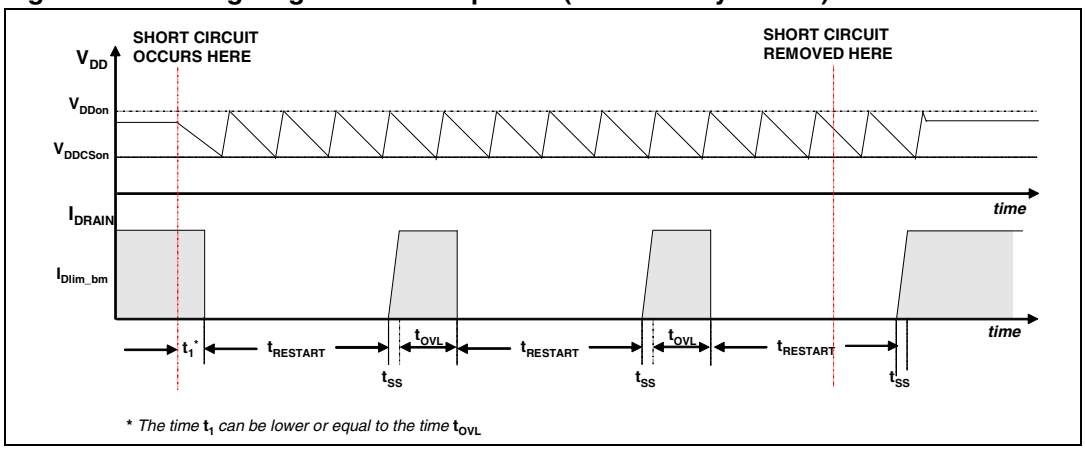
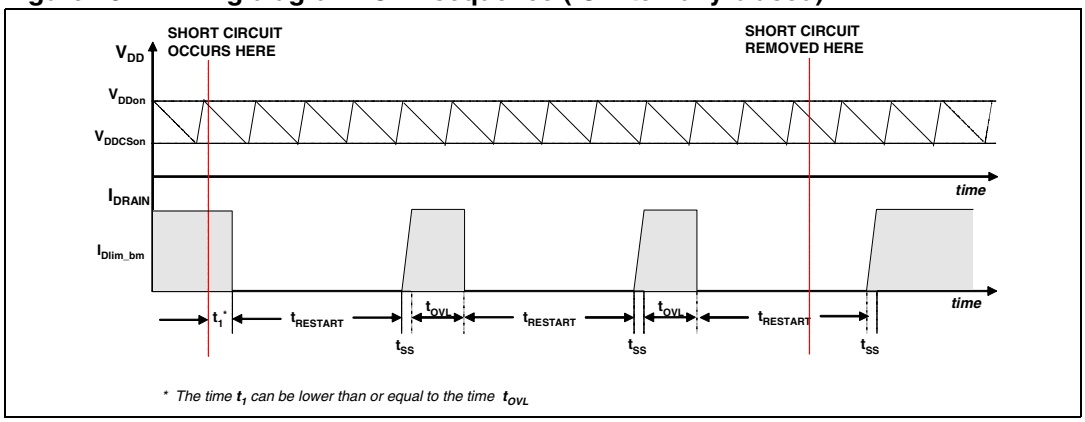


Figure 26. Timing diagram: OLP sequence (IC internally biased)



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

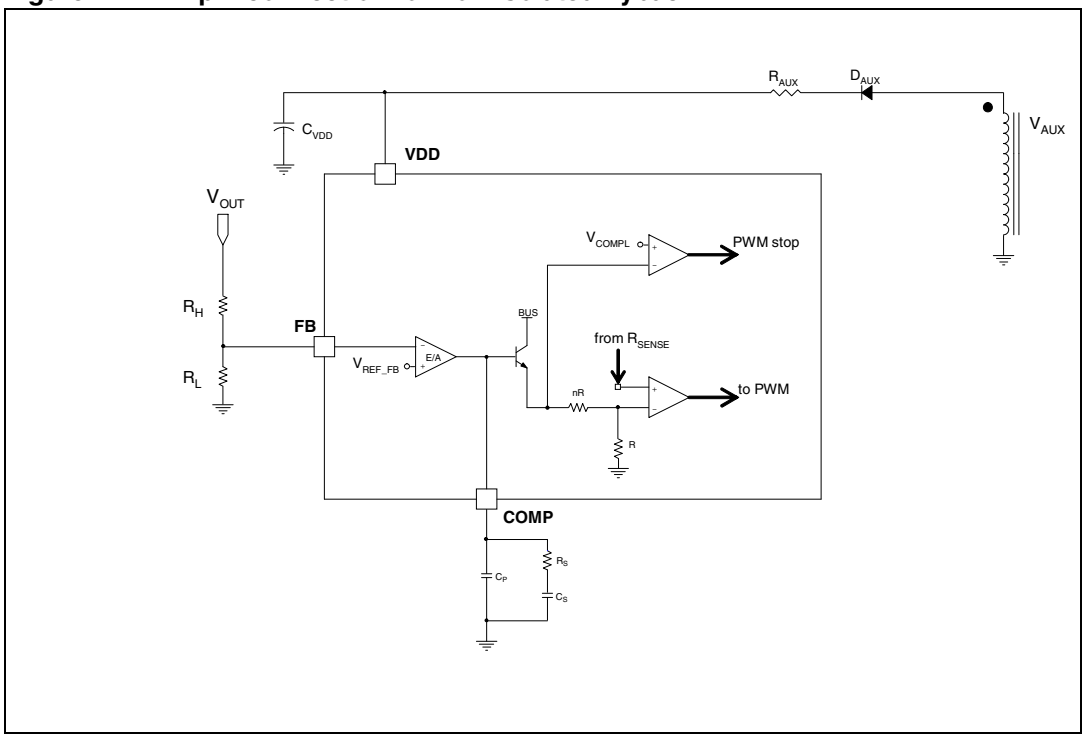
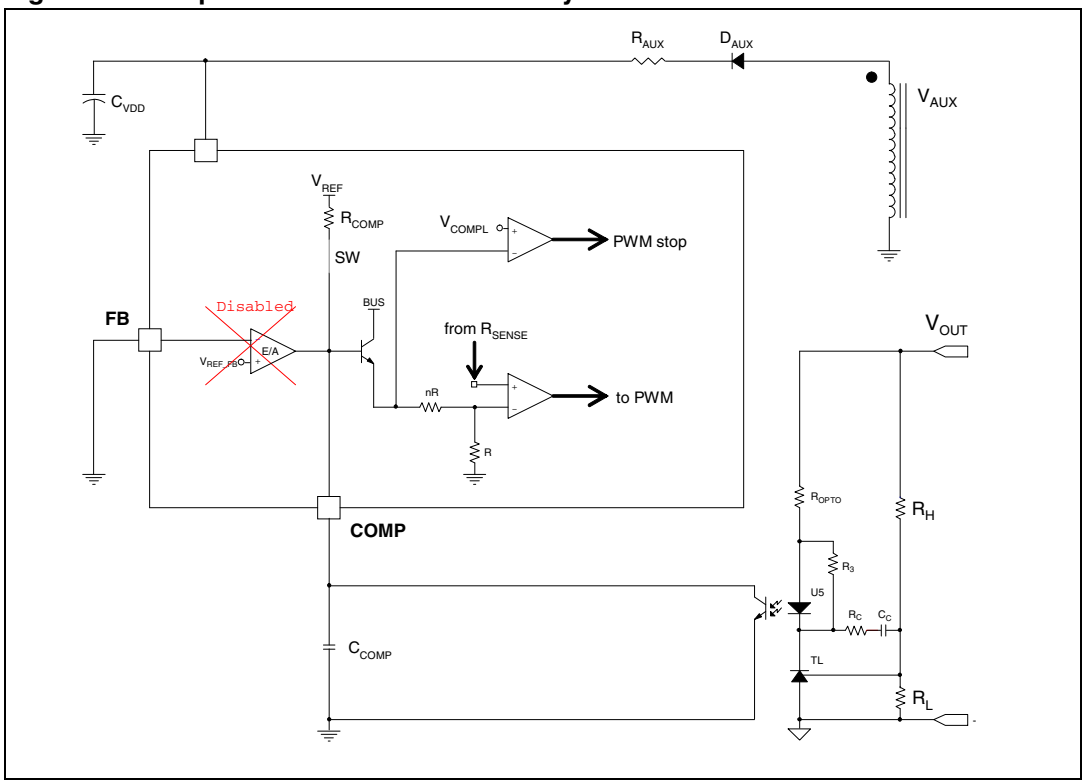


Figure 28. FB pin connection for isolated flyback



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

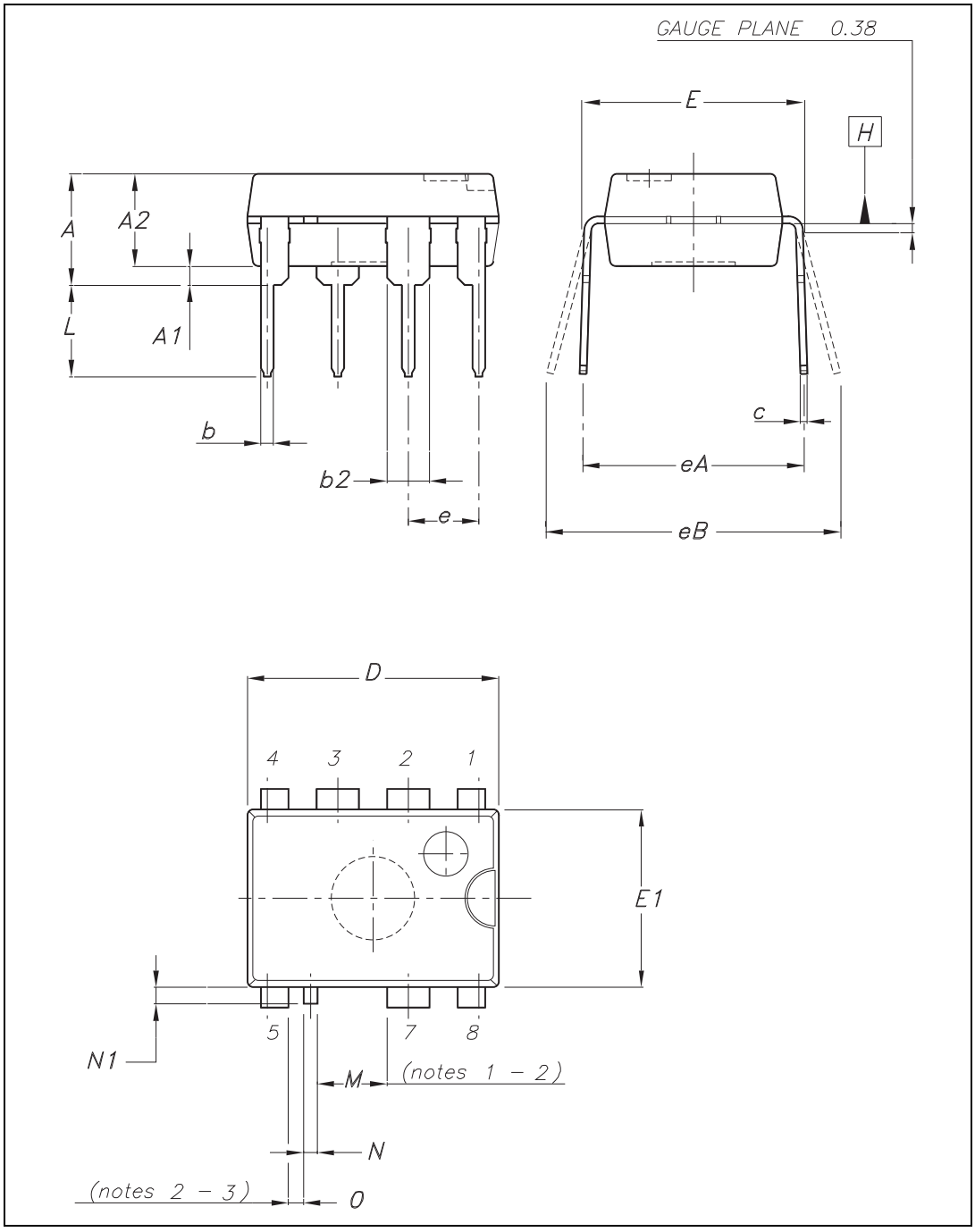
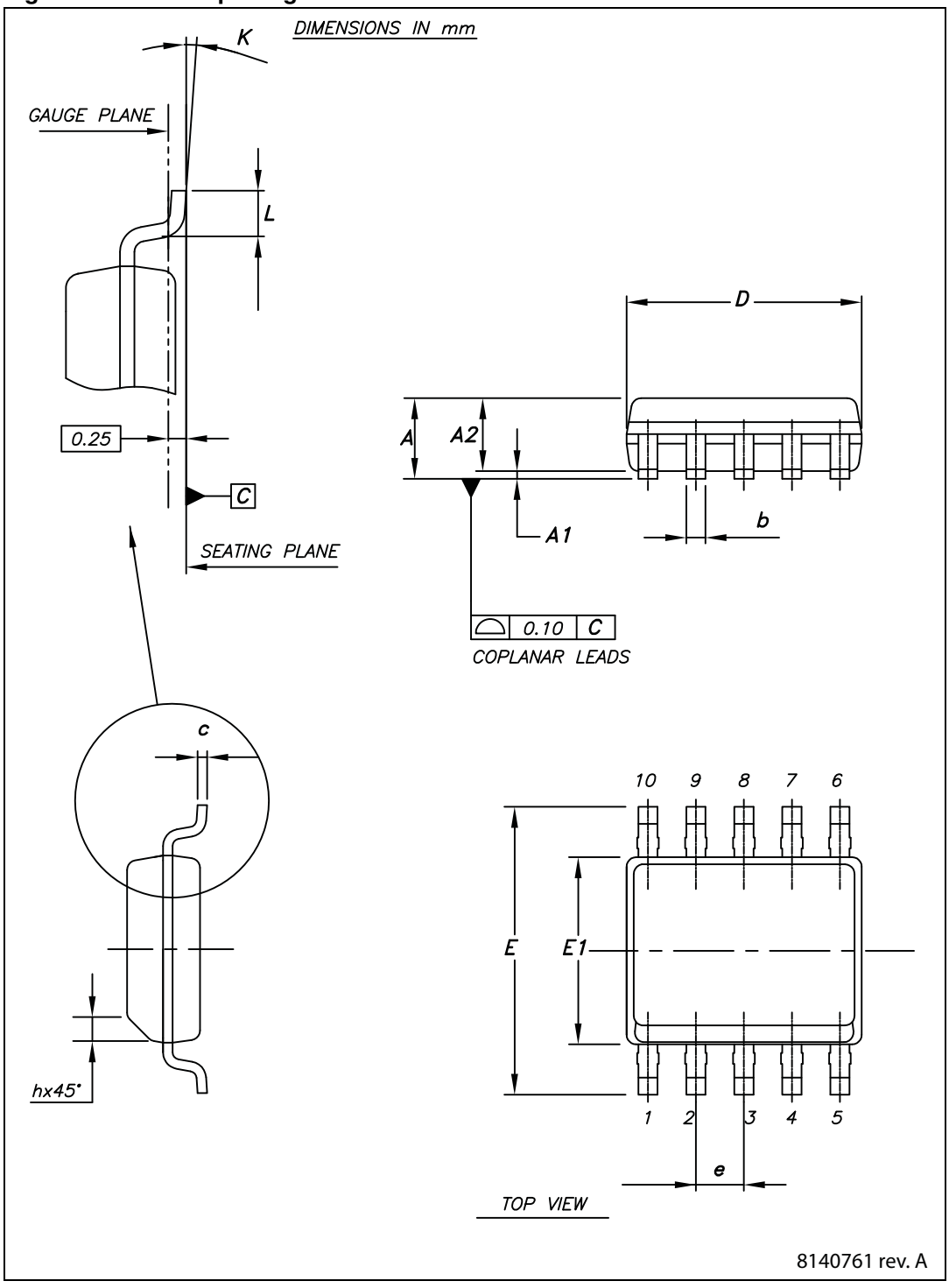


Table 9. SSO10 mechanical data

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.