PE4202

CRM/DCM PFC controller
Power Factor Correction

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Features

- Low total harmonic distortion (THD)
- Low start-up current (<5µA)
- Low operating current (<450µA)
- Disable function (<170µA)
- Under-voltage Lockout with >8V hysteresis
- Many protection features
- Decreased operating frequency at low output power
- High efficiency at high and low output power

- Integrated clamp resistor on G
- Fast driver switch 'off'
- Very fast Driver 'off' at over current
- Drives loads up to 5nF

Applications
- Active power factor correction
- Switch mode power supplies

General Description

The PE4202 is a high precision wide input range PFC controller IC for active power factor correction converters. It saves system cost due to the integrated highly accurate reference.

The IC operates in CRM (Critical conduction Mode) with voltage mode PWM (Pulse Width Modulation) control, and in DCM (Discontinuous Conduction Mode) under light load condition. The maximum switching frequency is clamped by an integrated delay circuit. Compensation for the voltage loop is provided by external devices to account for different applications.

PE4202 provides many protection functions, such as over voltage protection, open loop protection, supply under voltage lockout, output under voltage protection and peak current limit protection. These protection functions work with separat reference. If an error in the regulation reference occurs the protection function starts operation and prevents further damage.

The soft start function reduces the start up current and lowers the stress at the boost diode.
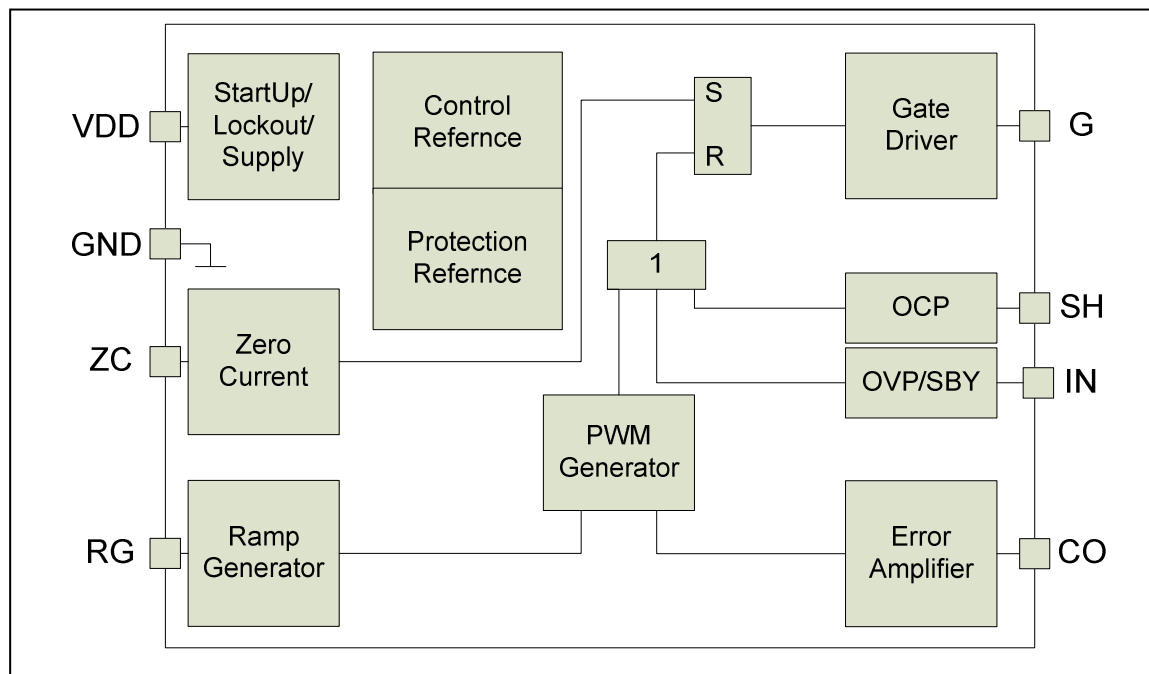
The current consumption drops below 170µA in disable mode.

Figure 1 - Block diagram

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1   Revision History

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Initial Version V1.0	05/2008		
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2   Ratings

2.1   Absolute Maximum Ratings

Table 1 – Maximum Ratings

Parameter	Symbol	Min	Type	Max	Unit	Notes
Operating Temp	$T_{junction}$	-40		125	°C	
Storage Temp	T_{Sto}	-55		150	°C	
Supply voltage	V_{DD}	-0.3		30	V	
Input voltage (Pin8)	V_{ZC}	-40		+40	V	
Input voltage (all other)	V_{IN}	-0.3		V_{DD}+0.7	V	
Output voltage	V_{OUT}	-0.3		V_{DD}+0.7	V	
Input current	I_{IN}			10	mA	

Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.

2.2   Operating Conditions

Table 2 – Operating Conditions

Parameter	Symbol	Min	Type	Max	Unit	Notes
Operating Temp	$T_{junction}$	-40	27	125	°C	
Supply voltage	V_{DD}	8		25	V	

2.3   Detailed Electrical Ratings

Table 3 - Static Operating Conditions ($T_{junction}$ = - 40 …125 °C; StartUp and Supply):

Parameter	Symbol	Min	Type	Max	Unit	Notes
Start Up Voltage	V_{ST}	16		22.5	V	
Lock Out Voltage	V_{LO}		7,5		V	
Supply current	I_{DD}			5	µA	before StartUp, V_{DD} < 14V
				450	µA	active Operation, no driver load
				170	µA	after StartUp, enable active
VDD over voltage protection	V_{DDOVP}	25		32	V	
Voltage at RG	V_{RG}	1.02	1.03	1.06	V	R_{RG} = 100KΩ

Table 4 - Static Operating Conditions ($T_{junction}$ = - 40 …125 °C; VDD=14V, Protection Function):

Parameter	Symbol	Min	Type	Max	Unit	Notes
Open Loop Protection / Enable (OLP), V_{IN} Threshold	V_{INOLP}	0.36		0.38	V	
Open Loop Protection / Enable (OLP), V_{IN} Hysteresis	HY_{NOLP}	70		90	mV	
Output Over Voltage Protection, V_{IN} Threshold	V_{INOVP}	2.55		3.65	V	
Output Over Voltage Protection, V_{IN} Hysteresis	HY_{INOVP}	10		20	mV	
Peak Current Protection V_{CS} Threshold	V_{CSPCP}	0.20		0.23	V	
CS Input current	I_{CS}	-0.5		0.5	µA	

Table 5 - Static Operating Conditions ($T_{junction}$ = - 40 …125 °C; VDD=14V, Regulation Function):

Parameter	Symbol	Min	Type	Max	Unit	Notes
Regulation Referenz	V_{RREF}	2.50		2.57	V	
Output source current	I_{COSO}	-11			µA	$V_{IN} = V_{RREF}$ -0.2V, V_{CO} = 2.5V
Output sink current	I_{COSI}	11			µA	$V_{IN} = V_{RREF}$ +0.2V, V_{CO} = 2.5V
ZC Threshold	V_{ZCREF}	50		70	mV	
ZC Input current	I_{ZC}	-0.3		-0.1	µA	

Table 6 - Static Operating Conditions ($T_{junction}$ = - 40 …125 °C; VDD=18V, Driver):

Parameter	Symbol	Min	Type	Max	Unit	Notes
Output Voltage High	V_{GH}	9	11	13	V	I_{OH} = -100mA
Output Voltage Low	V_{GL}		1.0	2.2	V	I_{OL} = 200mA
Maximum Output Voltage	V_{GMAX}			15	V	VDD = 20V
Output Voltage before StartUp and after LockOut	V_{GST}			1	V	
Clamping Resistor	R_G	16	20	28	KΩ	

Table 7 - Dynamical Operating Conditions (VDD = 14V, $T_{junction}$= -40 to 125 ºC):

Parameter	Symbol	Min	Type	Max	Unit	Notes
Driver rise time			6		ns	C_G = 1nF,V_G rise from 2V to 5V
Driver fall time			9		ns	C_G = 1nF, V_G fall from 5V to 2V
Current sense delay	t_{SC}		170		ns	C_G = 1nF, V_G<5V
Zero Current delay	t_{ZC}			700	ns	C_G = 1nF, V_G>5V
Max 'on' time	t_{ON}	14.5	17.8	23.5	µs	R_{RG} = 100KΩ, V_{CO}=4V
Min 'off' time	t_{OFF}	4.5	6	7.5	µs	R_{RG} = 100KΩ, V_{CO}=4V

3 Functional Description

3.1 General

The PE4202 is a 8 pin control IC for power factor correction converters. It is suitable for wide range line input applications from 85 to 285 VAC. The IC supports converter in boost topology and it operates in critical conduction mode (CRM) or discontinuous conduction mode (DCM) with output voltage control.

Under light load condition or if the input voltage goes near to zero, the control IC may enter into DCM. The voltage error amplifier controls the DC output voltage.

The IC is equipped with various protection features to ensure safe operating condition for the system and the device.

3.2 Typical Application Circuit

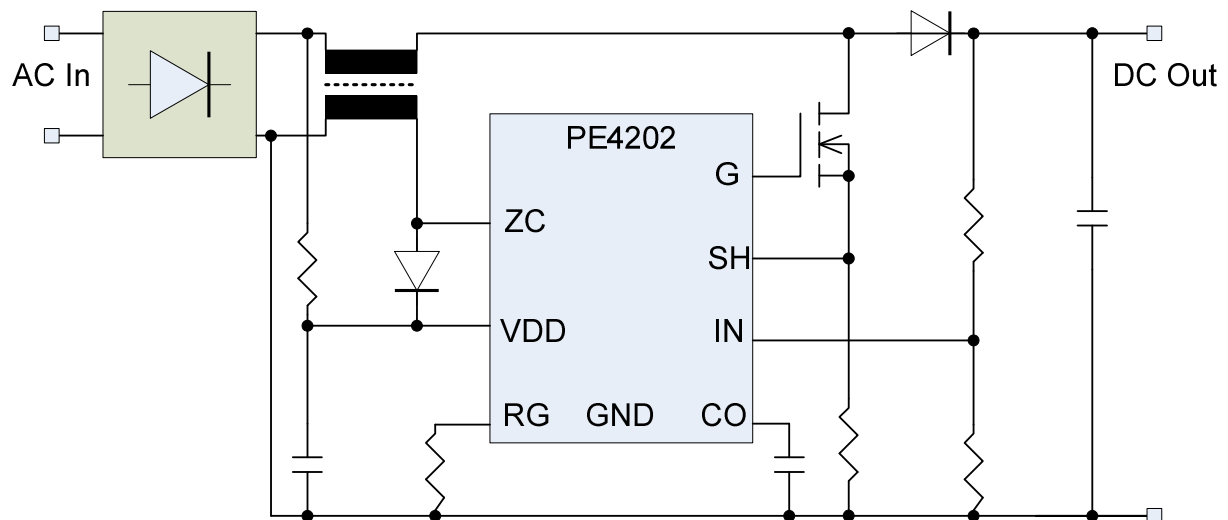Figure 2 gives an impression about the external components required for a typical application environment.
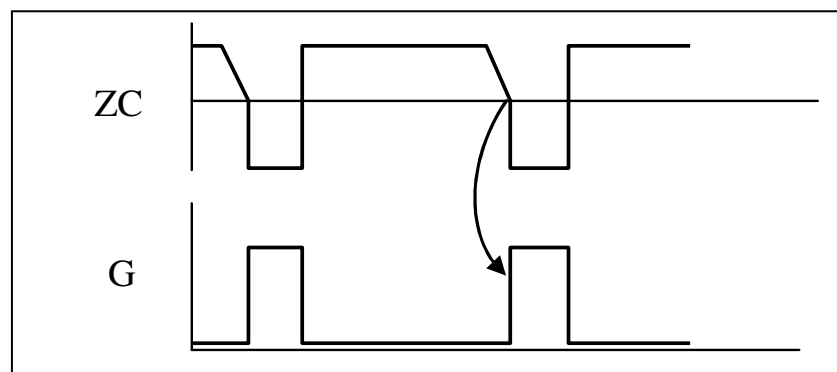

Figure 2 - External component schematic

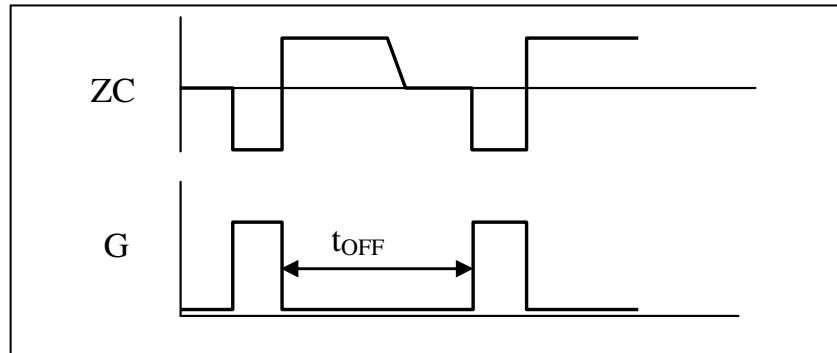Figure 3 - CRMode – driver output 'G' turns ON when voltage at 'ZC' crosses '0' line

Figure 4 - DCMode – Diver output 'G' turns ON when voltage at 'ZC' crosses '0' line and time t_{OFF} has passed

3.3 Power Supply Startup behaviour

The startup and under voltage lockout circuit monitors VDD at any time. If VDD rises above the startup voltage, the system begins with soft start and than enters the normal operation. If VDD falls below the lockout voltage the system turns OFF.

The IC can be turned OFF and can be forced into standby mode by pulling down the voltage at pin IN below the 'OLP' threshold.
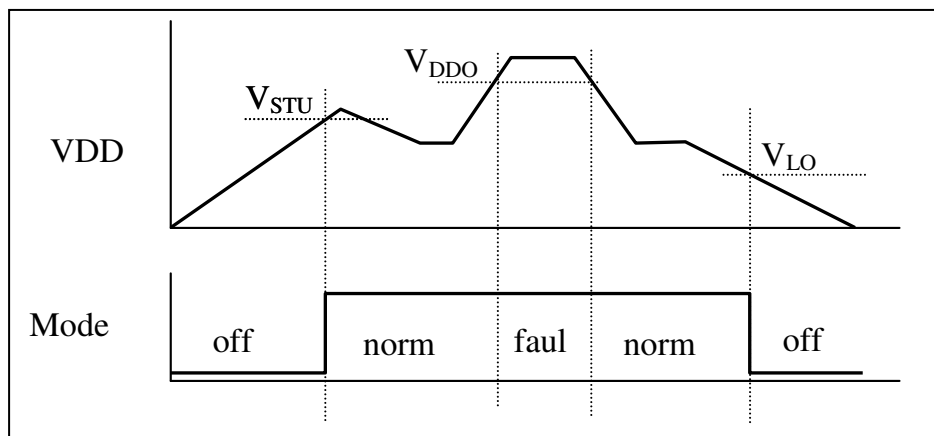

Figure 5 - Startup and shut down sequence

3.4   Gate driver behaviour

The gate driver is a totem pole driver, designed for direct drive of the external power MOSFET. The high output is clamped at V_{GMAX}.
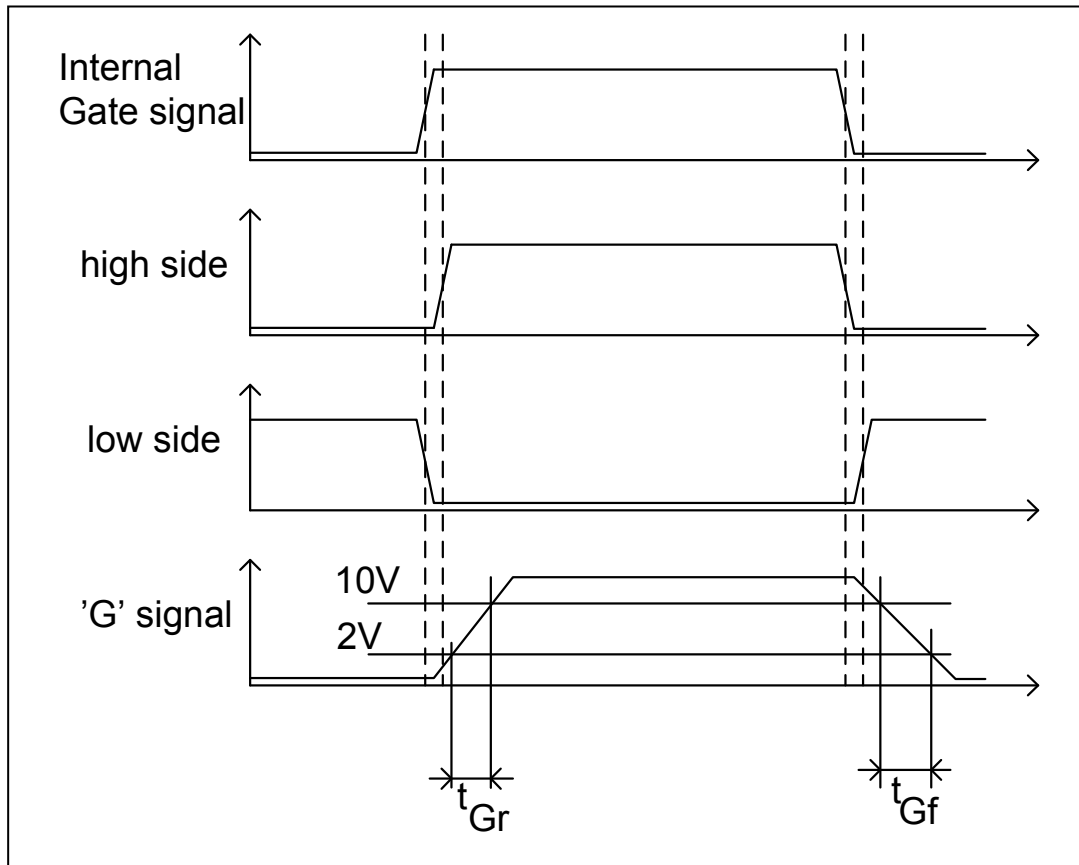

Figure 6 - t_{Gr} and t_{Gf} represent the Rise and Fall time for the Gate driver output assuming a capacitive load of 1nF

3.5   Fault Protection

The fault mode will be activated when any of the protection circuits cross the threshold. In fault mode the driver turns "off" or/and the duty cycle is reduced. The IC automatically resumes operation when the protection circuits returns above the threshold level.

1. Output over voltage protection (OOVP) is activated when the voltage at Pin "IN" rises above V_{INOVP}.
2. Open loop protection (OLP) is activated when the output voltage falls below V_{INOLP} or an insufficient input voltage for normal operation. This function can be used for an external disable of the IC.
3. Peak current limit protection (PCLP) is activated when the voltage at pin CS rises over V_{CSPCP}. The driver goes very fast (t_{SC}) to 'off'. An internal leading edge blending time suppresses switching noise.
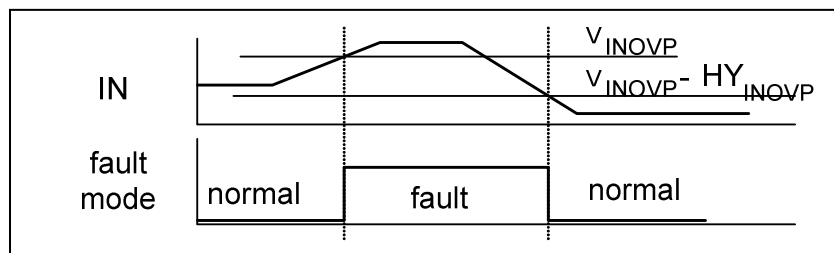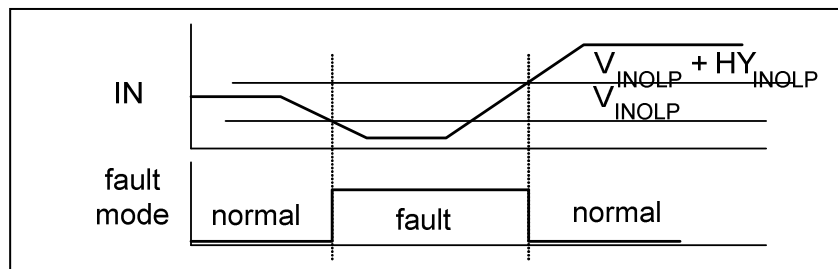

Figure 7 - Output Over voltage Protection

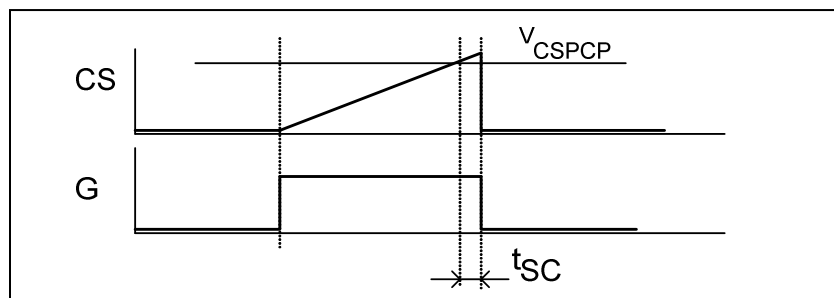*Figure 8 - Output Open Loop Protection*

Figure 9 - Peak current limit protection

3.6   Error Amplifier and Ramp Generator

The error amplifier is a transconductance amplifier with typical 120µS gain. On the output of the amplifier, Pin CO, is the compensation capacitor. This capacitor and current on the amplifier output create a low pass filter with a bandwidth lower than 20Hz.

The ramp generator slope is adjustment by the external resistor connected to the pin RG. The output of the error amplifier and the output of the ramp generator are compared to determine the driver 'off' signal. The driver 'on' time is maximum when the error amplifier output is higher then 4.5V.

If the error amplifier output voltage lower then 0.6V the driver become a 'off' signal. With the resistor at pin RG the maximum 'on' time is programmable. The necessary maximum 'on' time depends on the boost inductor, lowest AC line voltage, and maximum output power.

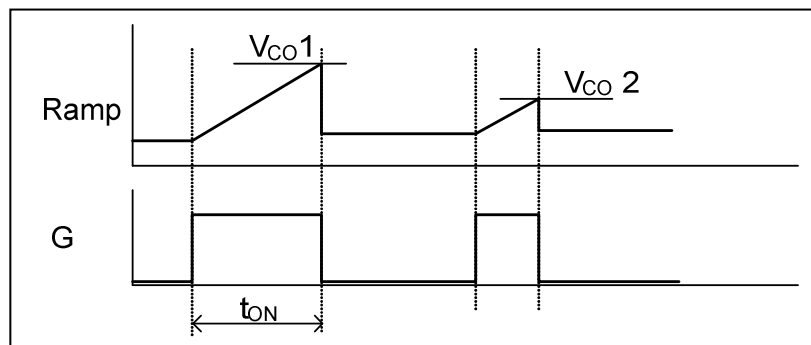The minimum driver "off" time where also set with the resistor at Pin RG.

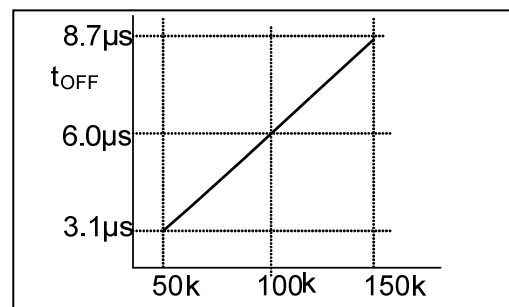*Figure 10 - Driver „t_{on}" time regulation*

Figure 11 - RG time range
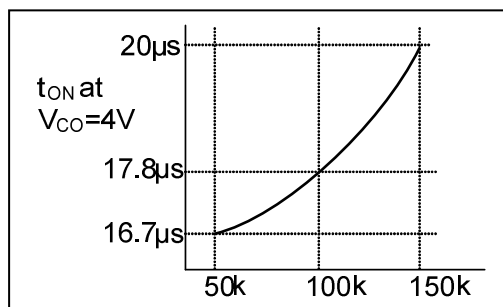
3.7   Zero Current Detection

The zero current detector generates a driver 'on' signal and if the minimum driver 'off' time has elapsed, the driver will turn 'on'. The driver 'on' delay reduces the switching frequency and the DCMode becomes active.
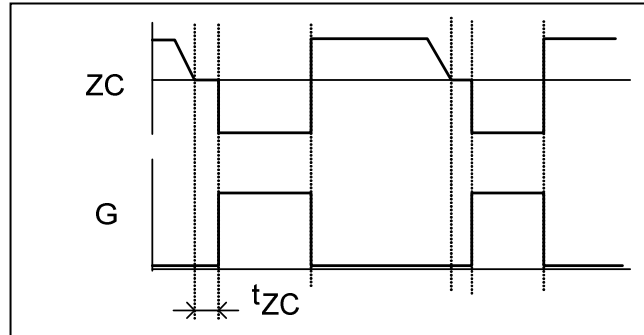
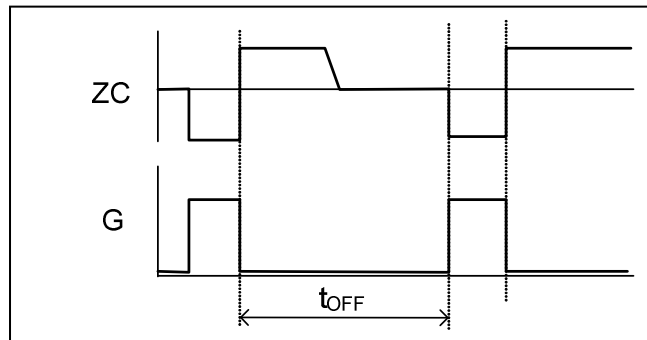

Figure 12 - CRM, time from ZC = 0V to Driver G switch „on"

Figure 13 - DCM, time t_{OFF} minimum driver „off", if voltage at ZC = 0V

4   Interfaces

Table 8 – Pin Configuration

Pin	Pad	Interface	I/O	Function
1	1	CO	I/O	Compensation
2	2	IN	I	Regulation Input
3	3	RG	I/O	Ramp Generator Resistor
4	4	SH	I	Current Protection Shunt
5	5	VDD	I	Power Supply
6	6	G	O	Driver Output
7	7	GND	I	Power Ground
8	8	ZC	I/O	Zero Current Detection

5   Package

The PE4202 comes in an SOIC8 package.
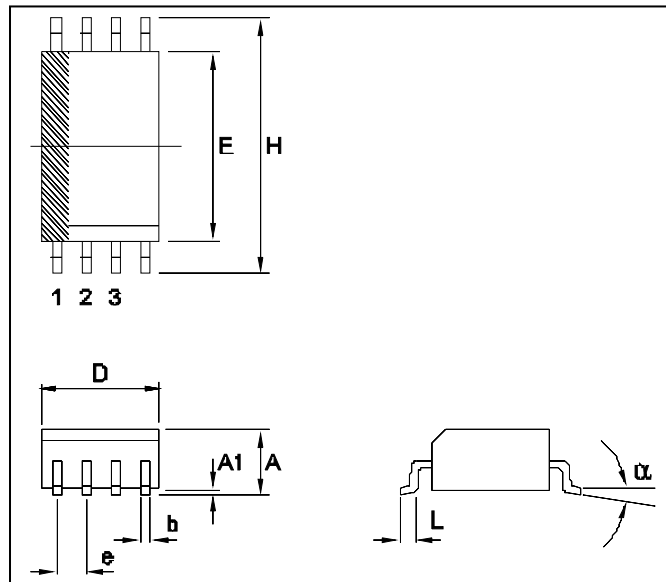
Dim.		D	E	H	A	A1	e	B	L	Copl	α
mm	min	4.80	3.80	5.80	1.35	0.10	1.27	0.33	0.40		0°
	max.	5.00	4.00	6.20	1.75	0.25		0.51	1.27	0.10	8°
inch	min	0.189	0.150	0.228	0.053	0.004	0.050	0.013	0.016		0°
	max.	0.197	0.157	0.244	0.069	0.010		0.020	0.050	0.04	8°

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