iP7306

Primary Side Voltage Regulation

Preliminary Datasheet Rev. 0.1

1. Description

iP7306 is a primary-side voltage regulation without second-side feedback circuitry. iP7306 is a controller for implementing constant voltage driver with power factor correction (PFC). By using primary-side regulation, it controls the output voltage accurately without the need of secondary side feedback components. The iP7306 operates in the quasi-resonant mode to achieve higher efficiency. iP7306 also integrates robust protection functions-output over voltage protection (Vout OVP), over load protection (OLP), VCC over voltage protection (Vcc OVP), VCC under voltage lockout (UVLO) and over temperature protection (OTP).
The power factor of iP7306 is higher than 0.9, and the output voltage regulation is less than ±5%. iP7306 is suitable for BLDC fan power supply.

2. Features

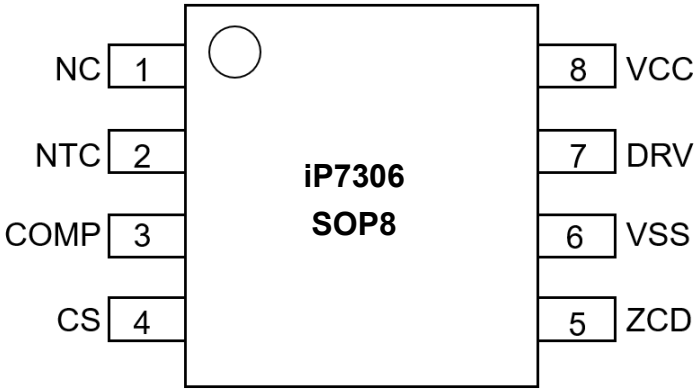
- Primary-side Voltage Regulation without Secondary-side Feedback Circuitry
- Power Factor Higher than 0.9
- Constant Voltage Regulation Less than ±5%
- Comprehensive Protection Functions
  - Output Over Voltage Protection
  - Over Load Protection
  - Vcc Over Voltage Protection
  - Under Voltage Lockout
- SOP-8 package.

3. Applications

- BLDC Fan Power Supply

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4. Pin Assignments



5. Marking Information

Product Name	Marking
iP7306	iP7306 xxxxxxxx X: Date code

6. Ordering Code

Ordering Code
iP7306

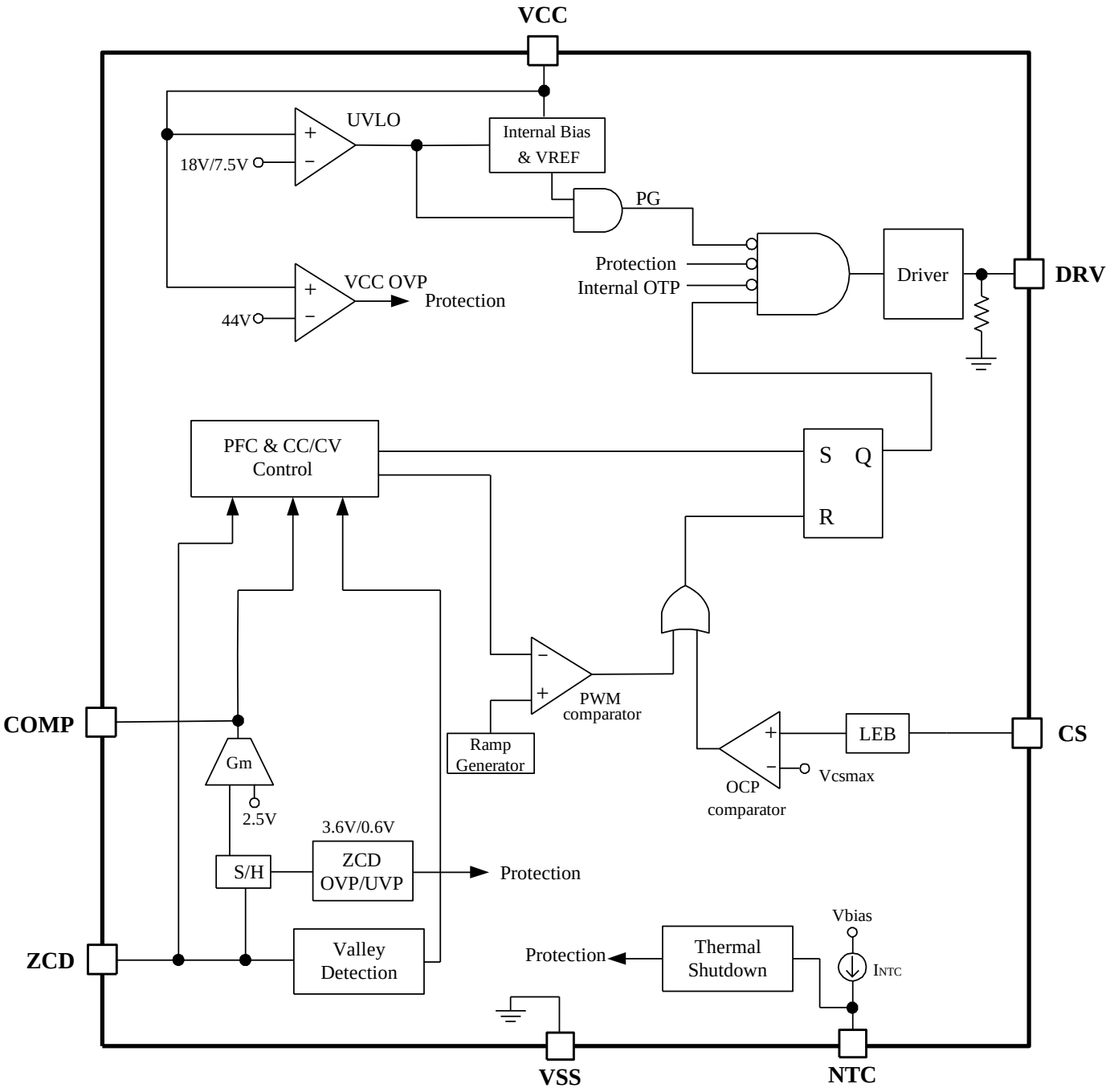
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7. Pin Definitions

Pin No.	Symbol	I/O	Description
1	NC	-	No Connected
2	NTC	Input	Connect to an NTC Resistor for Programmable Thermal Protection
3	COMP	Input	Loop Compensation. A Capacitor Should be Placed Between COMP and VSS
4	CS	Input	Current Sense. A Resistor is Connected to Sense the MOSFET's Current
5	ZCD	Input	Connected to a resistor divider from the Auxiliary winding to Sense the Valley and the Output Voltage
6	VSS	Ground	Ground
7	DRV	Output	Gate Driver Output for Driving the External Power MOSFET
8	VCC	Power	Power Supply

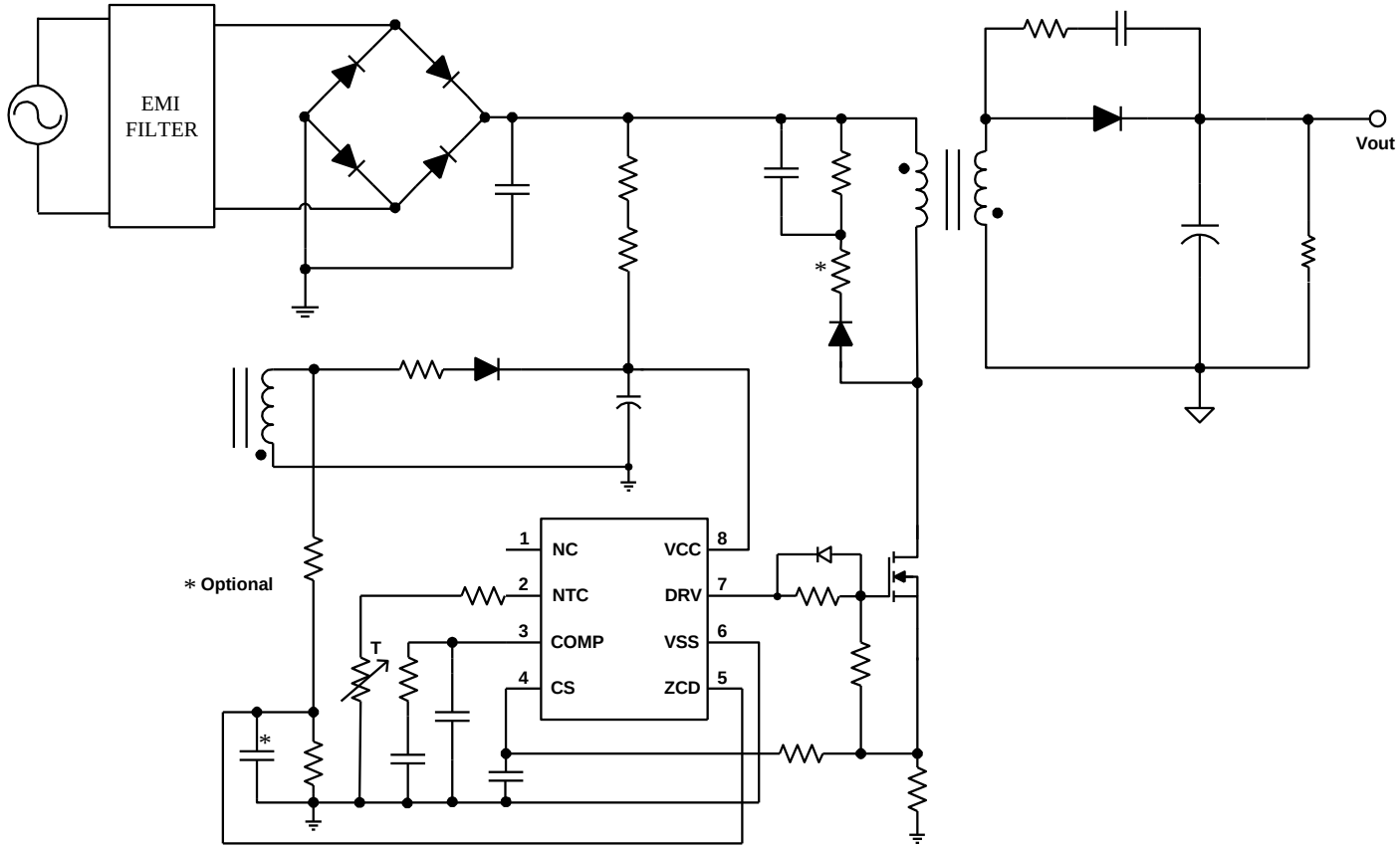
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8. Function Block



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9. Typical Application Circuit



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10. Electrical Characteristics

10.1 Absolute Maximum Ratings

Absolute maximum ratings indicate sustained limits beyond which damage to the device may occur. All voltage parameters are absolute voltages referenced to VSS, all currents are defined positive into any lead. The thermal resistance and power dissipation ratings are measured under board mounted and still air conditions. The ambient temperature is 25°C.

Parameter	Min	Max	Unit
VCC Supply Voltage, VCC to VSS	-0.3	46	V
DRV to VSS	-0.3	18	V
COMP, NTC, ZCD, CS to VSS	- 0.3	6	V
Maximum Junction Temperature	-	150	℃
Lead Temperature (Soldering 10 seconds)	-	260	℃
Storage Temperature Range	-60	150	℃

10.2 ESD Characteristic

	Parameter	Value	Unit
HBM	ESD (Human Body Mode)	±2000	V
MM	ESD (Machine Mode)	±200	V

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10.3 Recommended Operating Conditions

For proper operation, the devices should be used under the following recommended conditions. Unless otherwise specified, all voltage parameters are rated with VSS as a reference, current parameters are positive for the input port, and ambient temperature is 25°C.

Parameter	MIN	TYP	MAX	Unit
VCC Supply Voltage	10	-	36	V
Ambient Temperature	-40	-	105	°C

10.4 D.C. and A.C. Characteristics

10.4.1 Supply Voltage (V_{CC})

Symbol	Description	Condition	MIN	TYP	MAX	Unit
Supply Voltage (VCC)						
V_{CC_OVP}	VCC Over Voltage Protection	-	-	44	-	V
V_{CC_ON}	VCC Turn-On Threshold Voltage	-	-	18	-	V
V_{CC_OFF}	VCC Turn-Off Threshold Voltage	-	-	7.5	-	V
V_{CC_ET}	Entry VCC Mode Threshold Voltage	V_{CC} Falling	-	8.5	-	V
V_{CC_EX}	Exit VCC Mode Threshold Voltage	V_{CC} Rising	-	9	-	V
I_{CC_ST}	Start-up Current	$V_{CC} = V_{CC_ON}$-1V	-	11	-	uA
I_{CC_QU}	Quiescent Current	ZCD Pin and DRV Pin Open Circuit	-	1.3	-	mA

10.4.2 Current Sense (CS)

Symbol	Description	Condition	MIN	TYP	MAX	Unit
Current Voltage (CS)						
V_{CS_MAX}	Maximum Current Sense Limit Voltage for Over Load Protection	-	-	1.55	-	V
V_{CS_MIN}	Minimum Current Sense Limit Voltage for Output Under Voltage Protection	$V_{ZCD} \leqq V_{ZCD_UVP}$	-	0.4	-	V
t_{LEB}	Leading Edge Blanking Time	-	-	380	-	ns
t_{D_OCP}	Over Current Protection Debounce Time	$V_{COMP} \geqq$ 4.8V	-	100	-	ms

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10.4.3 Zero Current and Output Voltage Detector (ZCD)

Symbol	Description	Condition	MIN	TYP	MAX	Unit
Zero Current and Output Voltage Detector (ZCD)						
V_{ZCD_OVP}	ZCD Pin Over Voltage Protection Threshold Voltage	-	-	3.6	-	V
V_{ZCD_CV}	Constant Voltage Threshold Voltage	-	-	2.5	-	V
V_{ZCD_UVP}	ZCD Pin Under Voltage Protection Threshold Voltage	-	-	0.6	-	V
t_{D_ZCDUVP}	ZCD Pin Under Voltage Protection Debounce Time	-	-	15	-	ms
t_{BK_ZCD}	ZCD Pin Blanking Time	$V_{CS_PK} \geqq$ 150mV	-	1.15	-	us
		V_{CS_PK} < 150mV		0.80		us

10.4.4 Timing Control

Symbol	Description	Condition	MIN	TYP	MAX	Unit
Timing Control						
t_{OFF_MIN}	Minimum Off Time	-	-	2.2	-	us
t_{OFF_MAX}	Maximum Off Time	-	-	160	-	us
t_{OFF_GM}	Fixed Off Time for Green Mode	-	-	40	-	us
t_{OFF_ST}	Start Timer Period	-	-	160	-	us
t_{ON_MAX}	Maximum On Time	-	-	22	-	us

10.4.5 Gate Driver

Symbol	Description	Condition	MIN	TYP	MAX	Unit
Gate Driver (DRV)						
I_{DRV_SOURCE}	DRV Pin Source Current	-	-	350	-	mA
I_{DRV_SINK}	DRV Pin Sink Current	-	-	450	-	mA
I_{DRV_CLAMP}	DRV Pin Clamp Voltage	-	-	12	-	V

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10.4.6 External Over Temperature Protection

Symbol	Description	Condition	MIN	TYP	MAX	Unit
External Over Temperature Protection						
V_{NTC_OP}	NTC Pin Open Voltage	-	-	3.6	-	V
I_{NTC}	NTC Pin Current Source	-	-	85	-	uA
V_{NTC_SD}	External Thermal Shutdown Voltage	-	-	0.5	-	V
V_{NTC_RESET}	External Thermal Shutdown Reset Voltage			1.0		V
t_{D_NTCSD}	NTC Pin Thermal Shutdown Debounce Time			15		ms

10.4.7 Internal Over Temperature Protection

Symbol	Description	Condition	MIN	TYP	MAX	Unit
Internal Over Temperature Protection						
T_{OTP_SD}	Internal Thermal Shutdown Protection	-	-	150	-	°C
T_{OTP_SDHYS}	Internal Thermal Shutdown Protection Hysteresis	-	-	25	-	°C

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11. Function Description

The iP7306 is a constant voltage driver designed for BLDC FAN Power Supply applications. The controller can achieve high power factor values and low total harmonic distortion values without additional circuits.

11.1 Recommended Operating Conditions

The iP7306 regulates the output voltage by sensing the ZCD voltage (V_{ZCD_SH}). The figure below "ZCD Pin Voltage Sampling Method" shows the ZCD pin samples the V_{ZCD_SH} after the blanking time (t_{BK_ZCD}) when the MOSFET is turned off. The t_{BK_ZCD} is adjusted by the peak current voltage of CS pin (V_{CS_PK}), and the output voltage can be adjusted by R_{ZCD1} and R_{ZCD2} as shown in the Figure below "ZCD Pin Voltage Divider Resistor Schematic". The upper resistor (R_{ZCD1}) of voltage divider is determined by the following equation:

$$R_{ZCD1} = 355 \text{ x } \frac{N_A}{N_p} \; x \; 10^3 \; \Omega$$

Where N_P and N_A are the turns of the primary winding and auxiliary winding respectively. Therefore, the output constant voltage (V_{OUT_CV}) can be designed by the following equation:

$$V_{OUT_CV} = V_{ZCD_CV} \text{ x } \left(1 + \frac{R_{ZCD1}}{R_{ZCD2}}\right) x \; \frac{N_s}{N_A} - V_D$$

where V_{ZCD_CV} is the turns of the constant voltage threshold voltage, N_S is the secondary winding and V_D is the forward voltage of the secondary side rectifier diode.

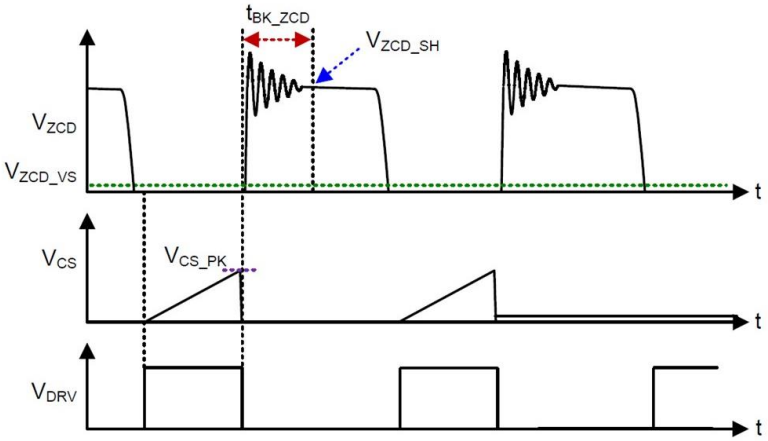


Figure 11-1 ZCD Pin Voltage Sampling Method

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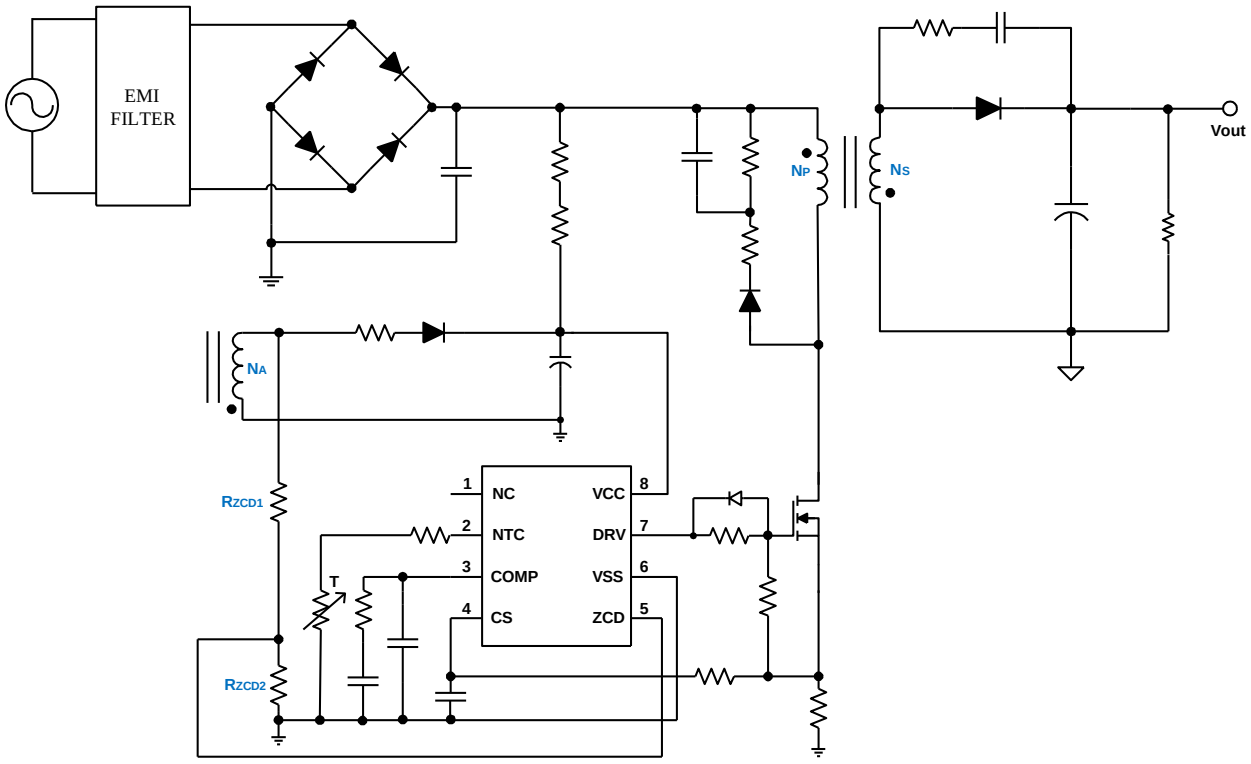


Figure 11-2 ZCD Pin Voltage Divider Resistor Schematic

11.2 Boundary Conduction Mode (BCM)

The power MOSFET is turned on by inductor current zero-crossing detection. When the inductor current is falling to the zero-crossing point, the voltage on the ZCD pin will detect the zero voltage and turn on the MOSFET. The BCM control provides low turn-on switching losses and high conversion efficiency.

11.3 VCC Self-charging Mode

When VCC pin voltage reaches the self-charging threshold voltage (V_{CC_ET}), the iP7306 will enter VCC self-charging mode to charge VCC to avoid triggering VCC UVLO during start-up or light load. It is highly recommended to design the VCC operating voltage higher than V_{CC_ET} to avoid the output voltage out of regulation.

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11.4 Soft Start

When the VCC pin reaches the turn-on threshold voltage (V_{CC_ON}) after power-on, the MOSFET will be turned on and the CS pin will be set to the minimum current sense threshold voltage (V_{CS_MIN}) to limit the power so as to reduce the voltage spike on the MOSFET. In the soft-start period, the on-time of DRV is determined by V_{CS_MIN} and the maximum off-time of quasi-resonant operation is limited by t_{OFF_MAX}. When the V_{ZCD} is higher than V_{ZCD_UVP}, the controller will set the maximum current sense threshold voltage (V_{CS_MAX}) and operate in normal operation, as shown in the following figure.

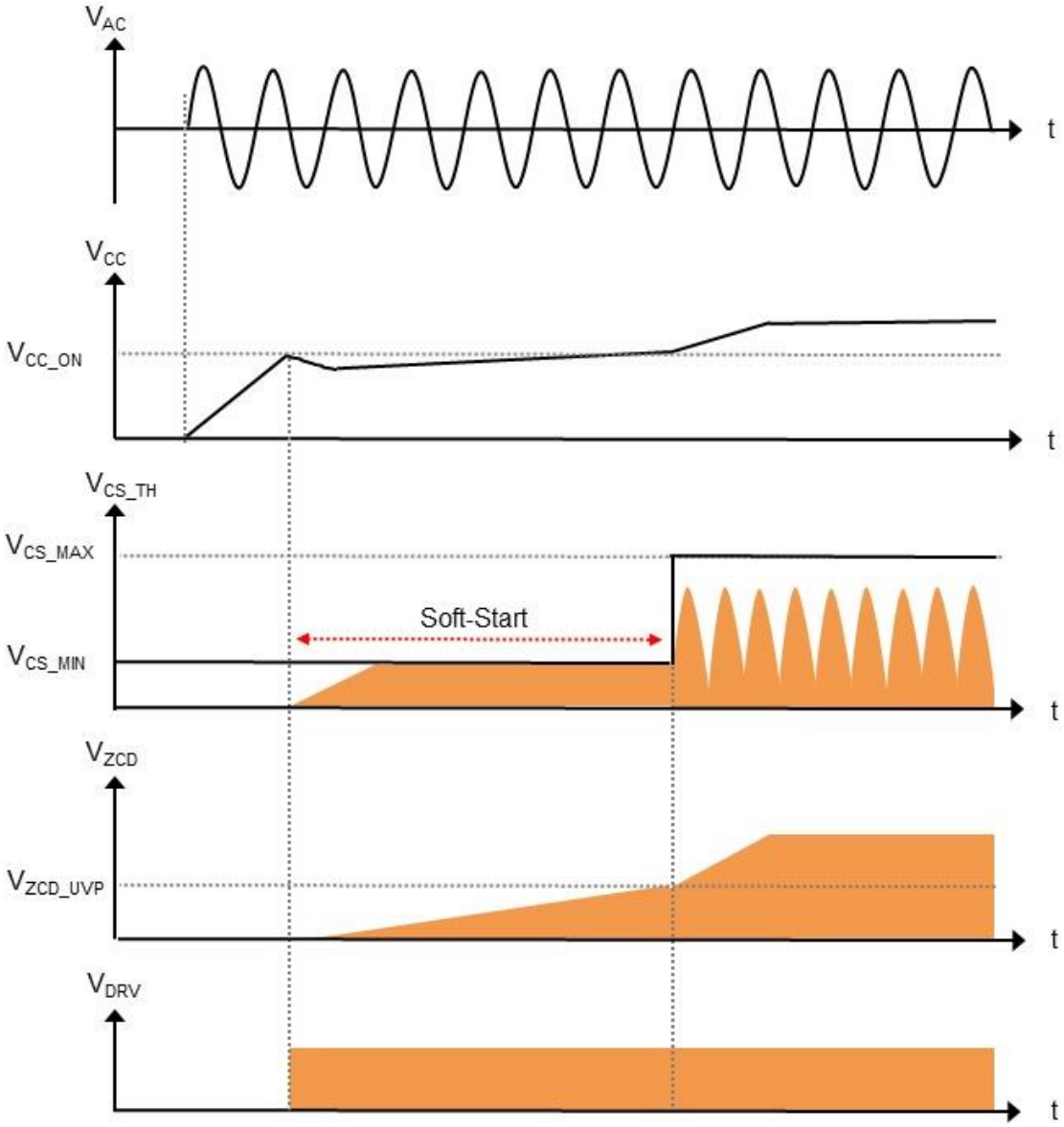


Figure 11-3 Soft Start Time Sequence

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11.5 Over Current Protection (OCP)

The iP7306 includes an over current protection function on the CS pin. An internal circuit detects the current level and when the current is larger than the over current protection threshold level (V_{CS_MAX}), the MOSFET will be turned off.

11.6 Output Short Circuit Protection (SCP)

The iP7306 determines whether the output is short-circuited by detecting V_{ZCD}. When the output is short-circuited and the V_{ZCD} is lower than V_{ZCD_UVP}, the controller will set the current sense limit voltage to V_{CS_MIN} to limit a lower output power to protect the power components, as shown in the following figure.

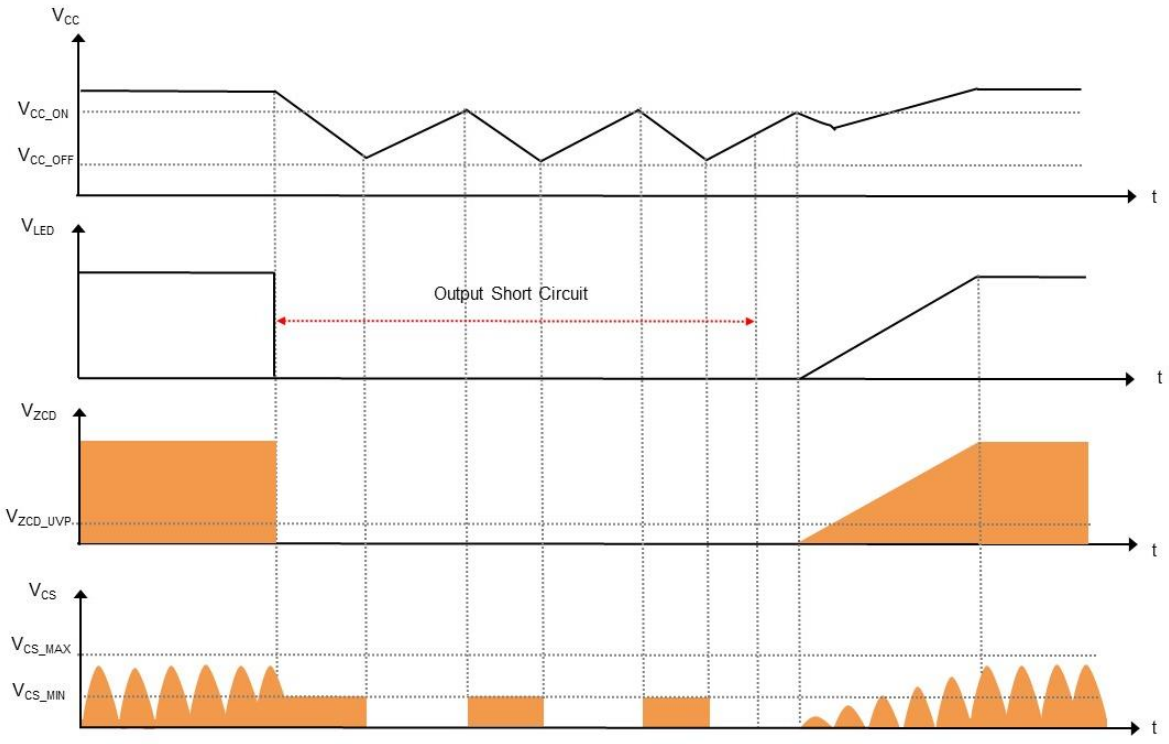


Figure 11-4 Short Circuit Protection Time Sequence

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11.7 VCC Over Voltage Protection (VCC OVP)

In order to prevent PWM controller damage, the iP7306 integrates a VCC OVP function. When the VCC voltage is higher than the OVP threshold voltage (V_{CC_OVP}), the PWM controller will stop operating immediately. If the VCC voltage decreases below the UVLO threshold voltage (V_{CC_OFF}), the controller will reset.

11.8 VCC Under Voltage Lockout (VCC UVLO)

The iP7306 has an integrated UVLO function which includes a hysteresis of 10.5V (Typ.). The PWM controller will switch on when the VCC voltage exceeds V_{CC_ON}. It will switch off when the VCC voltage is less than V_{CC_OFF}. The wide hysteresis characteristics will ensure that the device can be powered by an input capacitor during start-up. When the output voltage increases to a certain value after start-up, the VCC will be charged through auxiliary winding.

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11.9 External and Internal Over Temperature Protection

The iP7306 provides a programmable external over temperature protection (External-OTP) to protect the device from excessive heat damage. External-OTP is detected by connecting an NTC resistor between NTC pin and ground. When the NTC pin voltage is lower than the thermal shutdown threshold voltage (V_{NTC_SD}) for a time period of t_{D_NTCSD}, the system will stop operating, and then the controller will enter the auto-recovery mode until VNTC is higher than the reset voltage (V_{NTC_RESET}), the protection will be released. It is highly reminded that the NTC resistor can only be used to detect primary side components for safety requirements.

The iP7306 also has an internal over temperature protection (Internal-OTP). When the junction temperature exceeds T_{OTP_SD}, the controller will immediately turn off the DRV terminal. When the VCC voltage decreases below the V_{CC_OFF}, the controller will reset.

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12. Layout Guide

When designing the switching power supply, good layout can improve the system performance and reliability. The following layout practices are recommended.

- Keep the switching current loops as small and straight as possible to decrease noise coupling.
- RCD snubber loop is a high frequency switching loop. Keep it as small as possible.
- The DRV pin trace is also a high frequency loop. Keep it away from the sensitive ZCD feedback loop.
- The resistor divider connected to ZCD is recommended to be placed beside the IC.
- Separate signal ground and power ground. Connect grounds close to CIN.

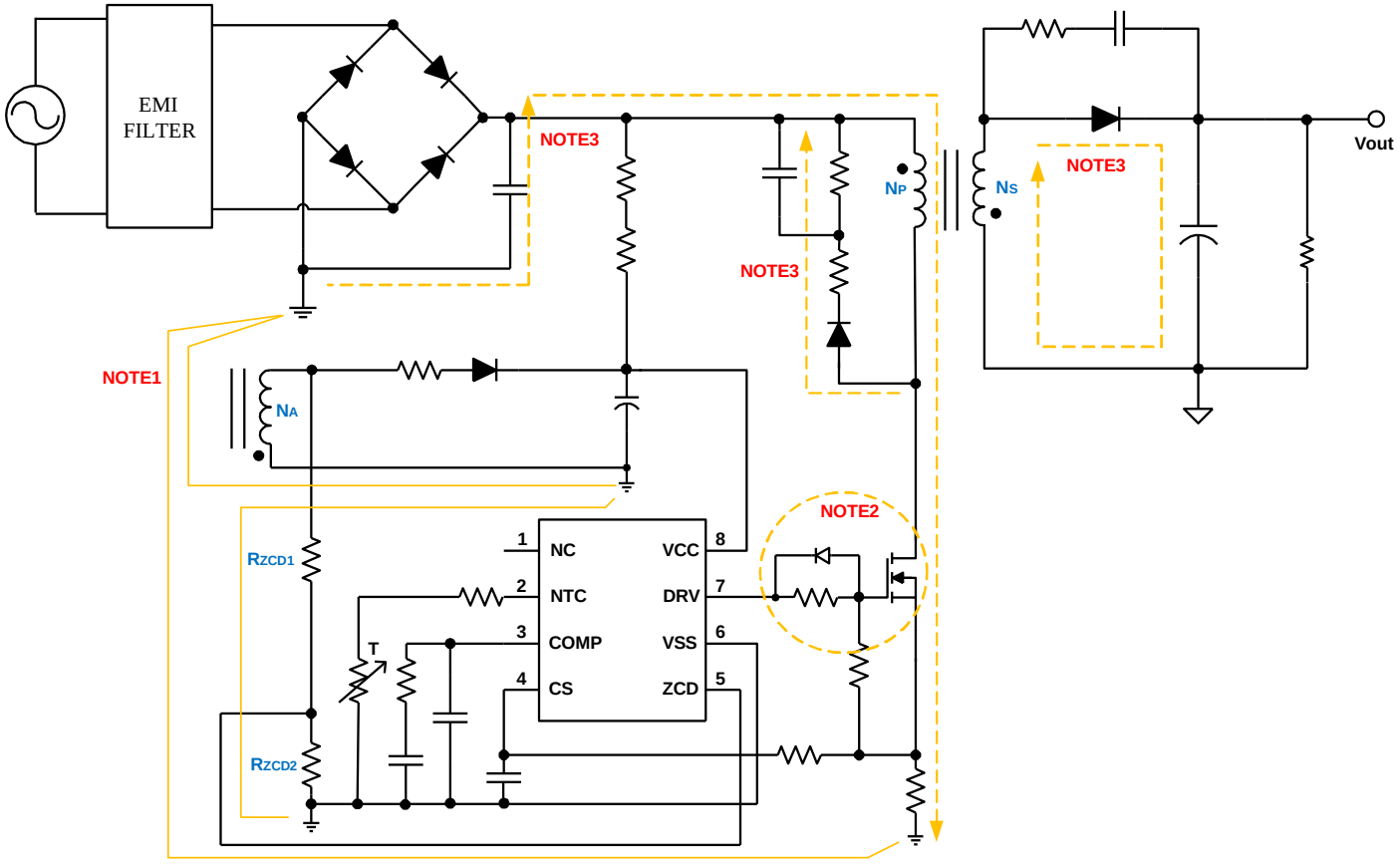


Figure 12-1 iP7306 Layout Guide

Note 1: Start grounding for less ground noise.

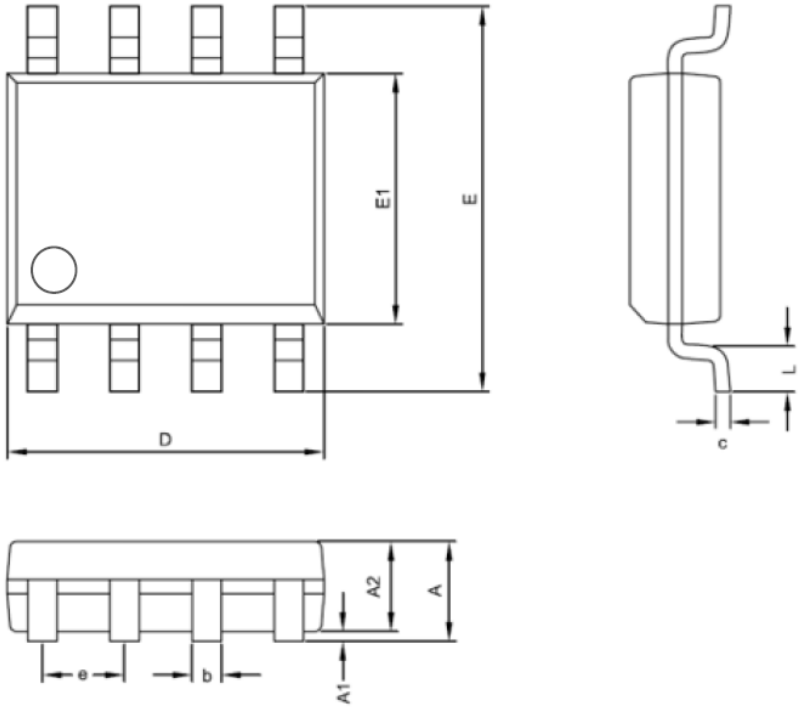
Note 2: Keep DRV loop away from sensitive ZCD sensing loop.

Note 3: Keep switching current loops as small as possible.

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13. Package Information

SOP8-8L Outline Dimensions



SYNBOL	Dimensions in mm		
	MIN	NOM	MAX
A	-	-	1.75
A1	0.1	-	0.25
D		4.90 BSC	
E		6.00 BSC	
E1		3.9 BSC	
c	0.10	-	0.25
b	0.31	-	0.51
e		1.27 BSC	
L	0.4	-	1.27

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