■ Introduction

CN1609 is internally integrated with PFM modulation controller and power BJT, and adopts advanced primary side control technology. It does not need optocoupler and other feedback elements on the periphery.It is dedicated to high performance, simplified AC-DC switching power supply with peripheral circuits. The internal CV and CC regulation make it have high output precision, stability and reliability.

The chip provides extremely comprehensive and excellent intelligent protection functions, including cycle by cycle over-current detection (external CS resistance can be set), overload protection, over-voltage protection, short circuit protection and soft start function. When the chip is light loaded, the chip uses frequency reduction adjustment and burping operation, which makes CN1609 have a low standby power consumption of 30MW.

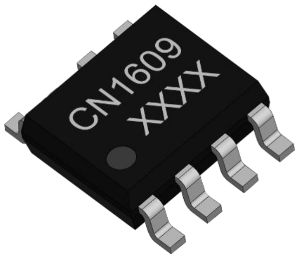
The frequency jitter and soft start function of the chip make it have good EMI characteristics. CN1609 provides a very good control mode for the customer's small power supply system developed with flyback architecture. It also provides a good implementation mode for temperature controller, intelligent switch and secondary market intelligent electricity meter.

■ Features

- Wide input AC range: 90Vac~265Vac
- Output power: 3~5W
- Up to 70KHz operating frequency
- Excellent system ESD performance
- Adjustable cable compensation (3%~8%)
- Adjustable line compensation
- High Efficiency Quasi Resonance Mode
- Over temperature protection
- Output over-voltage protection
- Output short circuit protection

■ APPLICATIONS

- Internet of things
- Mobile phone chargers
- low standby power supply



■ Ordering information

Part number	Package	Packing	Output power
CN1609	SOP7	3000/Reel	3~5W

■ Typical applications

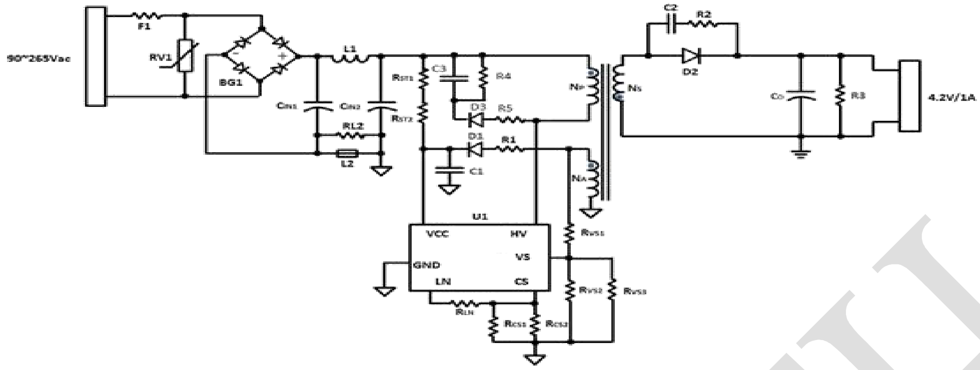
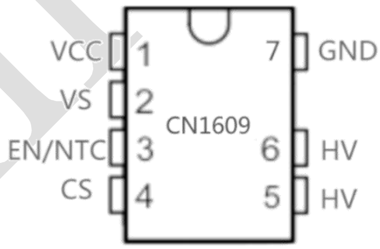


Fig.1 CN1609 based 4.2V 1A isolated power supply

Parameter	Symbol	Value	Unit	Condition
AC supply	V_{AC}	90~265	V	
Output voltage	VO	4.2	V	
Output current	I_{OMAX}	1	A	
Output current accuracy	ΔIo/Io	±5%		
Output voltage accuracy	ΔVo/Vo	±5%		
Cable compensation	Vcab/Vo	2%		
Switching frequency	f_{MAX}	65	KHz	Rated load
start time	T_{Start}	<2	S	At 220Vac

■ Pin definitions



CN1609			
Pin	**Pin Name**	**Pin Type**	**Pin Functions**
1	VCC	Power supply	Chip power input pinswitcher
2	VS	Input	Voltage sense of secondary winding
3	LN	Line	Line voltage compensation
4	CS	Input	Connected to power MOS source stage. Primary current sampling input

5,6	HV	Power	Connected to power MOS drain level
7	GND	Ground	Chip Reference

■ Absolute maximum ratings (Note 1)

Parameter	Name	Range	Unit
Collector voltage of Power BJT	HV	-0.5 to 850	V
Voltage at VCC to Ground	VCC	-0.5 to 40	V
VS input voltage	VS	-10 to 30	V
Voltage at LN to Ground	LN	-0.5 to 6	V
Voltage at CS to Ground	CS	-0.5 to 6	V
Maximum junction temperature	T_{JMAX}	150	°C
Welding temperature	T_{LEAD}	260	°C
Storage temperature	T_{STG}	-55 to 150	°C
ESD rating per ANSI/STM5.1-2001	HBM	2000	V
ESD rating per JEDEC JESD22-C101F	CDM	1000	V
Machine model	MM	200	V

Note1: Stresses over those listed under “Absolute maximum ratings” may cause permanent damages to the device. These are stress ratings only. Functional operation beyond those under “Recommended operating conditions” is not implied.

■ Recommended operating conditions

Symbol	Parameter	Range	Unit
HV	Power device voltage	0~750	V
VCC	Supply voltage	4~36	V

■ Thermal Resistance

Thermal resistance	θ_{JA}(SOP7)	130	°C/W
Over temperature protection	T_{OTP}*	150	°C

*Typical, guarantee by design

■ Electrical Characteristics

(Ta=25°C, unless otherwise specified)

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Power supply(VCC pin)						
VCC overvoltage protection	VCC_{OVP}			37		V
Quiescent current @ no load	I_{CC}	VCC=12V		60		μA
Startup voltage	V_{ST}		6	7.5	9	V
Minimum operating voltage	V_{UVLO}		2.5	3.7	4.7	V
Startup current	I_{ST}	VCC=Vst-1V		0.4	0.6	μA
Constant voltage control (VS pin)						
VS regulation voltage	V_{VS}		-2.95	-3.0	-3.05	V
Cable compensation current	I_{CAB}	At I_{OMAX}		50		μA
Min. operating frequency	f_{MIN}			300		Hz
Constant current control (CS pin)						
Shutdown voltage @full load	V_{CSMAX}		585	600	615	mV
Shutdown voltage @no load	V_{CSMIN}			200		mV
Pre-shutdown voltage	V_{CSPRE}/V_{CS}			83		%
Leading edge blanking	T_{LEB}			300		nS
Maximum duty of secondary winding conduction	D_{SMAX}			0.57		
Drive control						
Drive current	I_{DRV}			50		mA
Overdrive time	T_{OVD}			300		nS
Driving current rising time	T_{DR}	VCC=12V		60		nS
Pull down resistance	R_{DSON}	OUT=2V		3		Ω
Sinking current rising time	T_{SR}	VCC=12V		30		nS
Protection function						

Over temperature protection	T_{OTP}		130	160		°C
Over-temperature hysteresis	T_{HYST}			30		°C
Output over voltage	$\lvert V_{VSOVP}\rvert$			3.6		V
Short circuit voltage	$\lvert V_{VSHICCUP}\rvert$			0.9		V

■ Functional block diagram

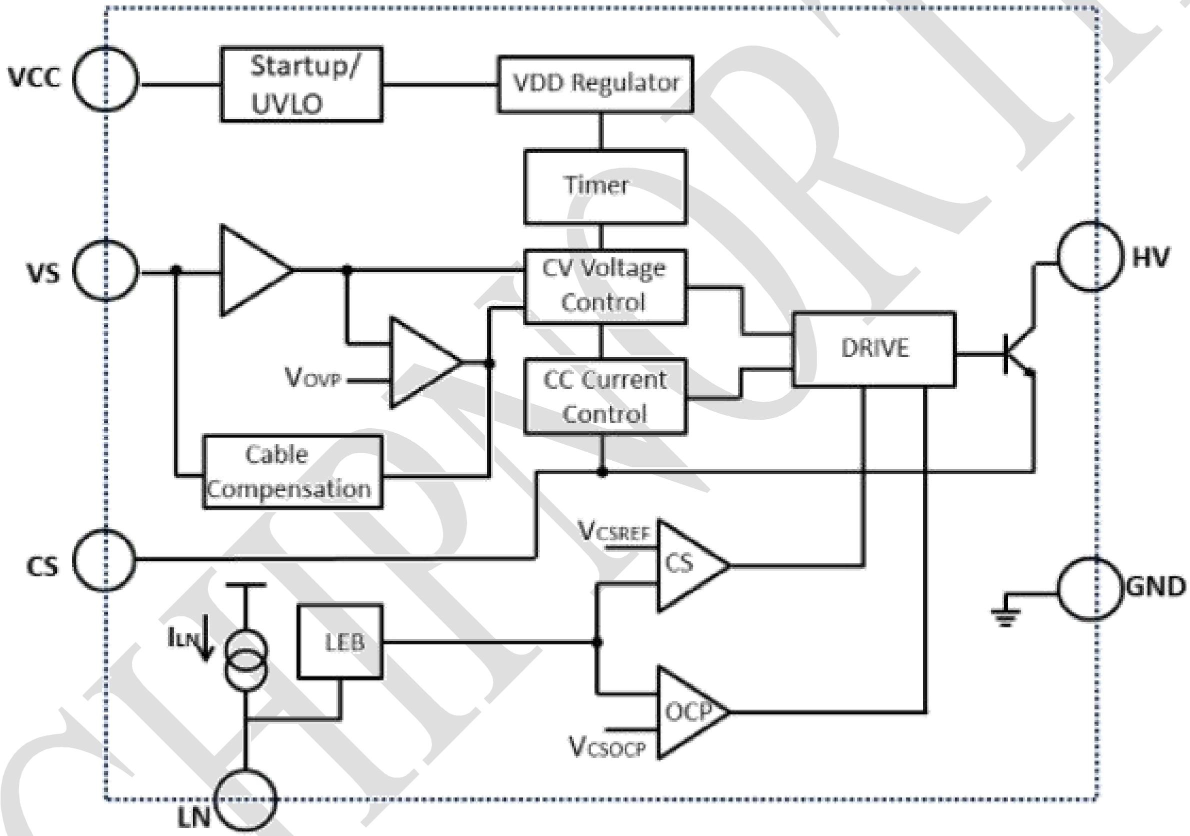


Fig.2 *CN1609 block diagram*

■ Principle of operation

The CN1609 is a high performance offline AC-DC switcher for LED isolated power supply applications. The devices operate in Discontinuous Conduction Mode (DCM) with Primary Side Regulation (PSR) to achieve Constant Voltage (CV) and Constant Current (CC) in the whole load range.

1. Power up and power down sequences

Refer to Fig.1 and Fig.2, after AC power supply is applied to the converter, VCC capacitor C1 is charged via the startup resistors R_{ST1} and R_{ST2}. When VCC voltage reaches startup voltage V_{ST}, the switcher U1 starts to work.

Then Driving current is generated to turn on the power device, and voltage on CS pin ramps up as the current through the primary winding generates voltage drop across the current sense resistor R_{CS}. When the CS pin voltage reaches V_{CSREF} after the Leading Edge Blanking (LEB) time T_{LEB}, the controller turns off the power device inside the switcher, then generates next turn on event according to the load conditions of the charger.

When the AC power is removed, the VCC voltage continues to drop due to there is no sufficient energy in the input capacitor $C_{IN1}$and C_{IN2}. When VCC voltage drops below V_{UVLO}, the power device is forbidden to turn on, the switcher waits for the VCC voltage to be higher than V_{ST} for a new round startup.

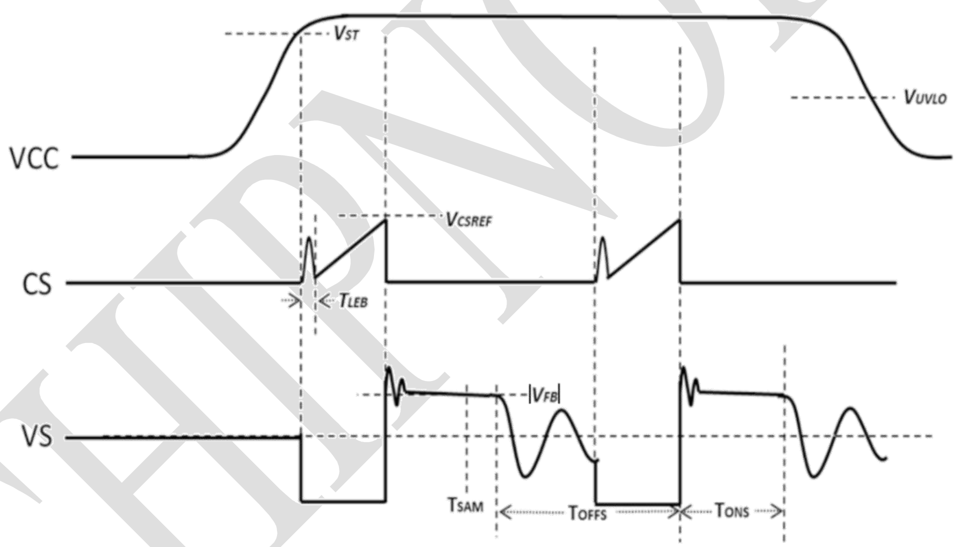


Fig.3 Switch waveforms for typical applications

2 . Constant Voltage (CV) operation

Constant voltage operation occurs when the load is between no-load and full-load. Output voltage is sensed at the VS pin, which is connected to the auxiliary winding via resistors R_{VS1} and R_{VS2}. The VS waveform is sampled at T_{SAM} , around 2/3 duration of the secondary winding conduction time(T_{ONS}). The sampled voltage is regulated at V_{VS} by the voltage control loop. The CV output is determined by the resistors R_{VS1}, R_{VS2} and the turn ratio of secondary winding to auxiliary winding (N_S/N_A). The output voltage at cable end is:

$$V_O=|V_{VS}|*(1+R_{VS1}/R_{VS2})*(N_S/N_A)$$

3 . Cable Compensation

The VS pin sinks a current proportional to load current to generate cable compensation voltage. The cable compensation current at I_{OMAX} is I_{CAB}. The cable compensation voltage V_{CAB} can be adjusted by setting the R_{VS1}, R_{VS2} values. Neglecting the forward conduction voltage of D2, the cable compensation voltage at full load is

$$V_{CAB} = I_{CAB} * R_{VS1} * (N_S/N_A)$$

The output voltage at PCB end is

$$V_{OPCB} = V_O + V_{CAB}$$

The cable compensation percentage is approximately

$$V_{CAB}/V_O = I_{CAB} * (R_{VS1}//R_{VS2}) / |V_{VS}| - 0.02$$

The -0.02 item in the formula is to compensate load regulation..

4 . Constant Current (CC) operation

Constant current operation occurs when load is heavier than the rated maximum load. Output current is limited by setting the maximum ratio of secondary winding conduction time (T_{ONS}) to non-conduction time (T_{OFFS}) to restrict the output power.

$$I_{OMAX} = 0.5 * (V_{CSMAX}/R_{CS}) * (N_P/N_S) * D_{SMAX}$$

Where $D_{SMAX} = T_{ONSMAX} / (T_{ONSMAX} + T_{OFFSMIN}) = 0.57$.

During the constant current operation, if the output voltage is lower than a specified voltage V_{SC} for 48mS(typical), the output is regarded as shorted to ground, the switcher will go into hiccup mode (startup then shutdown repeatedly) until the output voltage is higher than V_{SC} again.

$$V_{SC} = V_{VSHICCUP} * (1 + R_{VS1}/R_{VS2}) * (N_S/N_A) + I_{CAB} * R_{VS1} * (N_S/N_A) - V_{D2}$$

5 . Adjustable line compensation

Since there is a constant delay time from the CS pin voltage reaching the given VCS reference to the power transistor turning off, the real primary peak current value always has a gap with the ideal value. The gap value changes with different input line voltage, which is caused by different current rising slope, results in different system constant current value.

In order to eliminate the constant current deviation due to the line voltage, the adjustable line compensation is introduced to design. By sensing the voltage of VS pin which is linear to the line voltage, a current (I_{LN}) proportional to line voltage flows out from the CS pin to the resistor R_{LN}, and create an adjustable compensation voltage to clear up the primary current gap, so that the excellent line regulation of output current will be achieved.

$$I_{LN}= [Vindc*(Naux/Np)*Rvs2/(Rvs1+Rvs2)]/1187Kohm$$

$$Vcs\_line=I_{LN}*R_{LN}$$

$$Vcs\_real=Vcs\_line+Vcs$$

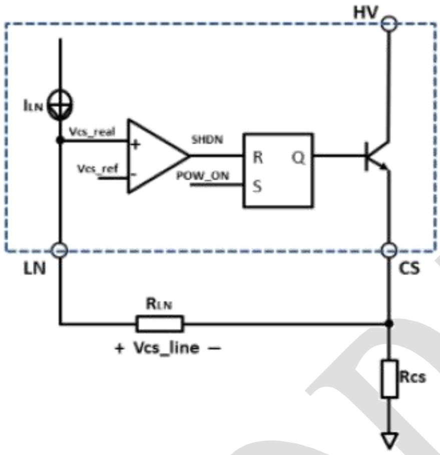


Fig.4 ***Adjustable line compensation circuit***

6. Switching frequency control

The CN1609 works in Pulse Frequency Modulation (PFM) mode to control output voltage and current. As shown in Fig.5, the CS voltage at the power device turnoff instant varies from V_{CSMIN} to V_{CSMAX} when the load increases from no load to full load. Operating frequencies varies from 1KHz at no load to up to 70KHz at full load. The power device is turned on when the ring voltage is down to its valley (quasi-resonant switching). This can reduce turn on losses of the power device. It can also generate switching period jittering to reduce EMI.

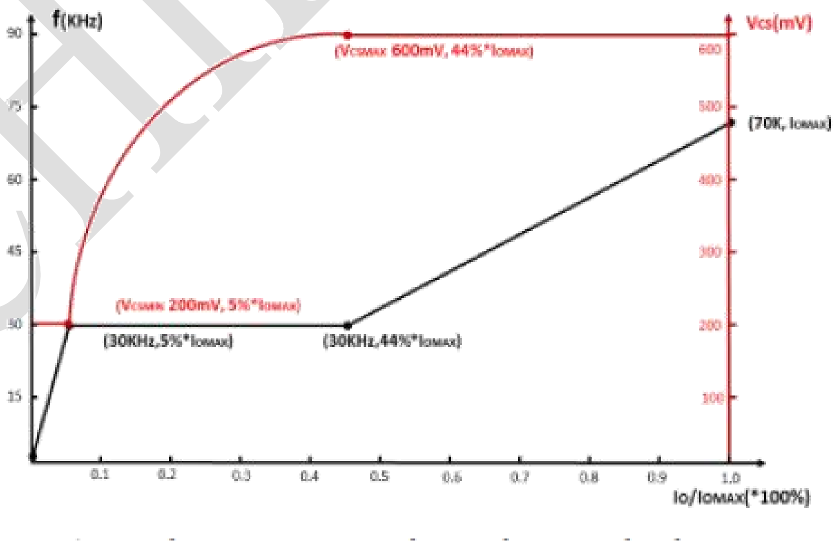


Fig.5 ***Switching frequency and CS voltage v.s. load current***

7. AC input over voltage protection

When the AC source voltage is over a specified value VAC_{OVP} for 4 successive switching cycles, power device will be turned off until the AC source voltage drops below VAC_{OVP}.

$$VAC_{OVP}=0.707*VCC_{OVP}*(N_P/N_A)$$

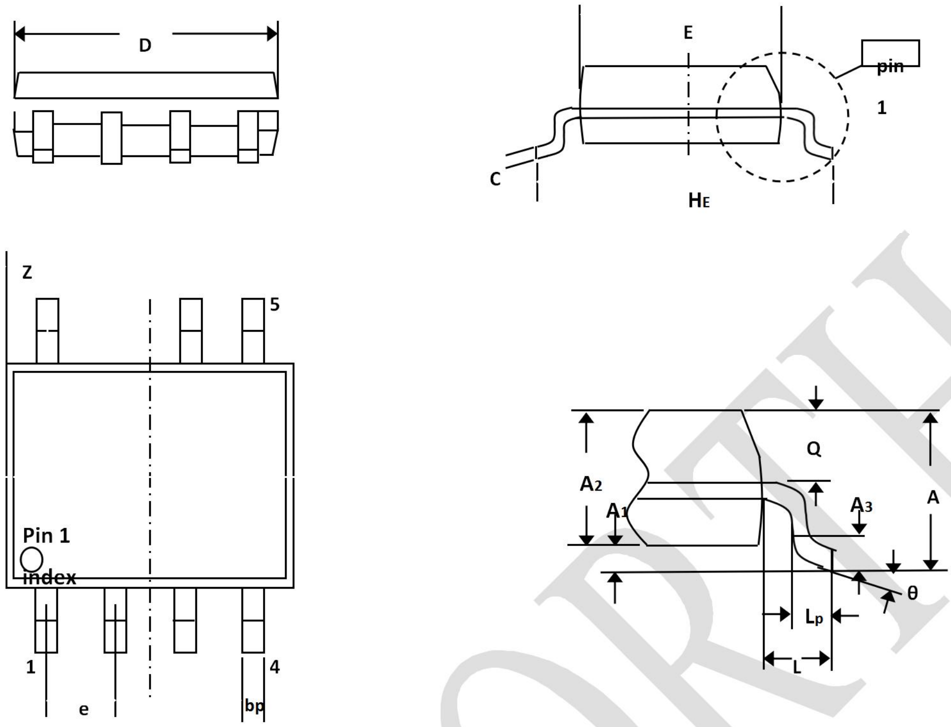
8. Output over voltage protection

When the output voltage is over a specified value V_{OVP} for 4 successive switching cycles, power device will be turned off until a new startup event begins.

$$V_{OVP}=|V_{VSOVP}|*(1+R_{VS1}/R_{VS2})*(N_S/N_A)+I_{CAB}*R_{VS1}*(N_S/N_A)-V_{D2}$$

■ Mechanical dimensions

SOP7



UNIT	A	A1	A2	A3	bp	c	D	E	e	HE	L	Lp	Q	Z	θ
mm	1.75MAX	0.10 0.25	1.25 1.65	0.25	0.31 0.51	0.17 0.25	4.8 5.0	3.8 4.0	1.27	5.8 6.2	1.05	0.4 1.2	0.6 0.7	0.3 0.7	0° 8°

■ ORDER INFORMATION:

date	Version	Revision notes	Reviser
2020.3.27	V1.0	Initial data compilation	ZhangSongfeng