1. General Description

G1138P-S is a high performance offline PWM Power switch for low power AC/DC charger and adaptor application. It operates in primary side regulation.Consequently,opto-coupler and TL431 could be eliminated.

Proprietary Constant Voltage (CV) and Constant Current (CC) control is integrated as shown in the Fig.1. In CC control,the current and output power setting can be adjusted externally by the sense resistor R_{CS} at CS pin. In CV control, multi-mode operations are utilized to achieve high performance and high efficiency.

In addition, good load regulation is achieved by the built-in cable drop compensation. Device operates in PFM in CC mode as well at large load condition and it operates in PWM with frequency reduction at light/medium load.

G1138P-S offers perfect protection function with auto-recovery features including Cycle-by-Cycle current limiting （OCP）, VDD UVLO and OVP,VDD clamp, Secondary rectifier Diode short protection etc.

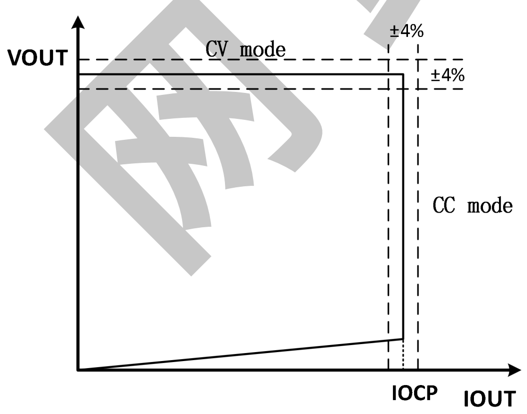


Fig.1. Typical CC/CV Curve

Features

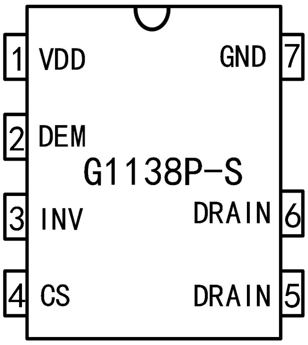
- ◆ Built-in High-Voltage Power MOS
- ◆ 4% CV and CC Regulation at Universal AC input
- ◆ Standby Power consumption less than70mW
- ◆ Programmable CV and CC Regulation
- ◆ No audible noise over entire operating range
- ◆ Programmable cable drop compensation
- ◆ Integrated line voltage and load voltage constant current compensation
- ◆ Built-in Leading Edge Blanking (LEB)
- ◆ Comprehensive protection coverage
  - •VDD under voltage lockout with hysteresis（UVLO）
  - •VDD over voltage protection（VDD OVP）
  - •Cycle-by-Cycle current limiting
  - •Output over voltage protection （Output OVP）
  - •Secondary rectifier diode Open and short circuit protection
  - •Secondary winding Open and short circuit protection
  - •FB pin to GND short circuit protection
- ◆ Pb-free DIP7

Applications

- ◆ Cell Phone Charger
- ◆ Digital Cameras Charger
- ◆ LED Driver
- ◆ Small Power Adaptor
- ◆ Auxiliary Power for PC, TV etc.
- ◆ Linear Regulator/RCC Replacement

2. Products Information

2.1 Pin configuration



DIP7 Package

Fig.2. G1138P-S Pin Configuration

Pin Name	I/O	Description
VDD	Power Input	Power Supply
DEM	Analog Input	Functions pin.Connecting two resistors from Vaux to ground can adjust output OVP trigger voltage.
INV	Analog Input	The Voltage feedback from auxiliary winding. Connected to resistor divider from auxiliary winding reflecting output voltage.
CS	Analog Input	Current sense input. Connected to primary current sensing resistor.
DRAIN	Output	HV MOSFET Drain Pin. The Drain pin is connected to the primary lead of the transformer
GND	Ground	Ground

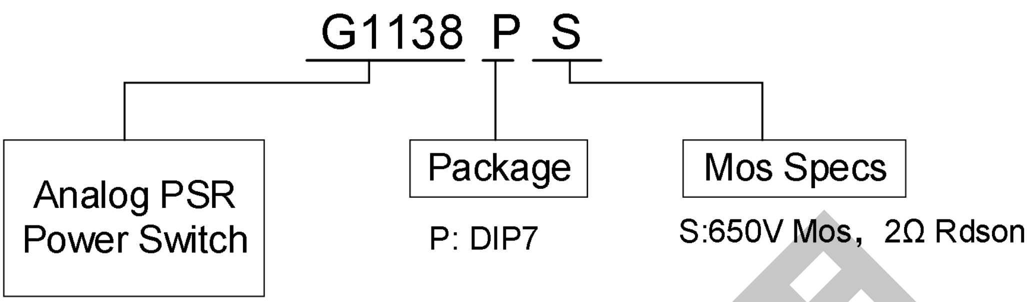
2.2 Series Description

Product	Package	85~264VAC output power	200~240VAC output power
G1138P-S	DIP7	18W	20W

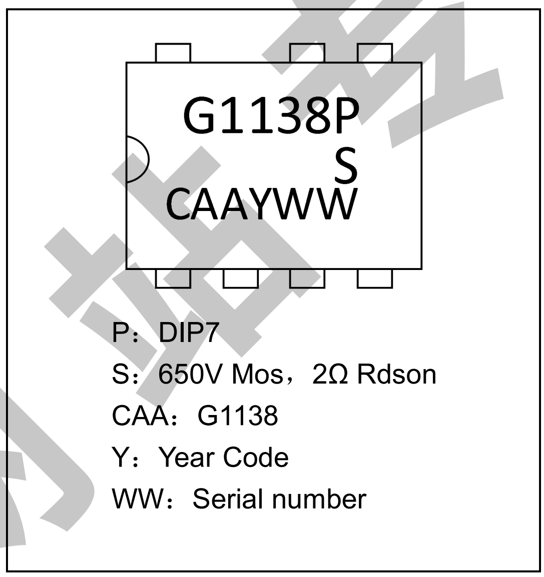
Note: Maximum practical continuous power in an Adapter design with sufficient drain pattern as a heat sink, at 40℃ ambient. Higher output power is possible with extra added heat sink or air circulation to reduce thermal resistance.The recommended output power does not mean that this power can be made, which is determined by the actual ambient temperature and the actual shell size and whether the glue is filled.

2.3 Ordering Information

Part Number	Marking ID	Package	Packing
G1138P-S	G1138PS	DIP7	50/Tube



2.4 Marking Information



Year Code

A	B	C	D	E	F	G	H	I	J	K	L	M
2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
N	O	P	Q	R	S	T	U	V	W	X	Y	Z
2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038

2.5 Block diagram

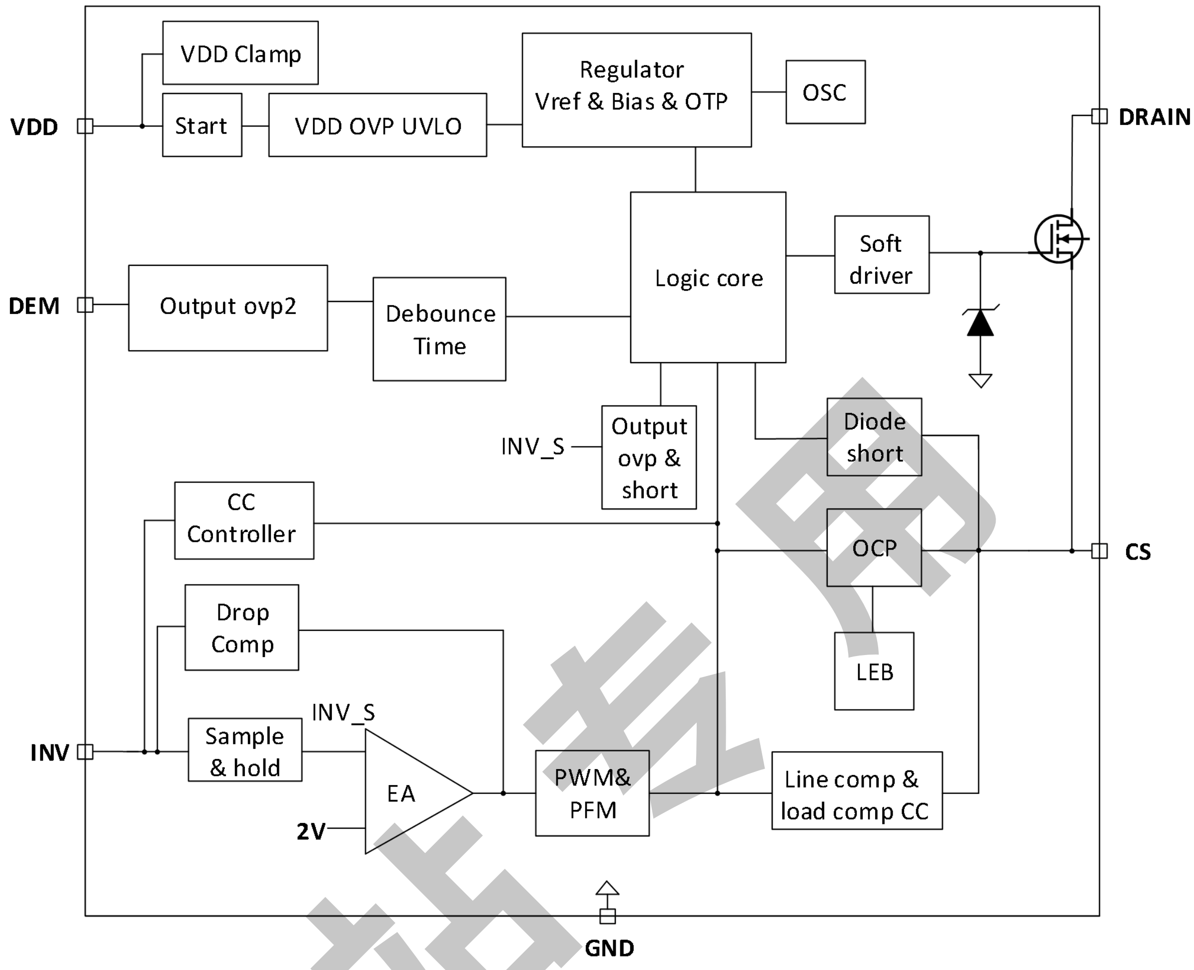


Fig.3. Block Diagram

3. Absolute Maximum Ratings

Description	Absolute Maximum Ratings
VDD Voltage	-0.3 to VDD_clamp
HV MOSFET Drain Voltage	-0.3 to BVdss
VDD Zener Clamp Continuous Current	10 mA
DEM Input Voltage	-0.3 to 7V
CS Input Voltage	-0.3 to 7V
INV Input Voltage	-0.3 to 7V
Max Operating Junction Temperature T_J	150℃
Min/Max Storage Temperature T_{stg}	-55 to 150℃
Lead Temperature (Soldering, 10secs)	260℃
Package Dissipation Rating for DIP7 $R_{\theta JA1}$ [2]	75℃/W

Notes:

1. Stress beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. Exposure to absolute maximum-rated conditions for extended periods may affect device reliability
2. Drain Pin Connected to 100mm² PCB copper clad.

Recommended Operation Ratings

Parameter	Ratings	Unit
VDD Supply Voltage	10~25	V
Environment Temperature	-20~85	℃
Maximum Operation frequency	90	kHz
Minimum Operation frequency	35	kHz

Notes:

The maximum operation frequency is not set in IC, and the maximum operation frequency is set in scheme design.

4. Electrical Characteristics

(TA = 25℃, VDD=18V, unless otherwise noted)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
Supply Voltage（VDD Pin）						
I_{VDD_ST}	Start Current	VDD= UVLO_OFF-0.5V		2	10	uA
I_{VDD_OP}	Operation Current	VDD=18V		0.6	0.9	mA
UVLO_ON	VDD Under Voltage Lockout Enter	VDD falling	6.8	7.8	8.8	V
UVLO_OFF	VDD Under Voltage Lockout Exit	VDD rising	14	15	16	V
V_{DD_OVP}	VDD Over voltage protection	Ramp up VDD until Gate is off	26	28	30	V
$V_{DDClamp}$	VDD clamp voltage	I_{VDD}=5mA	32	34	36	V
Current Sense（CS Pin）						
T_{LEB}	LEB time			500		nS
V_{TH_OC}	Over current threshold		490	500	510	mV
T_{D_OC}	Over current detection and control delay			100		nS
Error Amplifier Section（INV Pin）						
V_{REF_EA}	Reference voltage for Error Amplifier		1.98	2.00	2.02	V
V_{INV_OVP}	Output over voltage threshold based INV		2.3	2.4	2.5	V
$V_{thCC\_shutdown}$	CC mode shut down threshold			0.55		V
$T_{D\_CC\_shutdown}$	CC mode shut down debounce time			30		ms
V_{INV_DEG}	Degaussing comparator threshold			20		mV
T_{off_min}	Minimum turn off time			2		uS
T_{off_max}	Maximum turn off time		3.6	4	4.4	mS
I_{Cable_max}	Maximum cable compensation current		45	50	55	uA
Over-temperature protection						
T_{SD}	OTP shutdown Threshold			150		℃
T_{SD_R}	OTP shutdown recovery			115		℃
Functions pin（DEM Pin）						
V_{output_ovp}	Voltage threshold for		2.9	3	3.1	V

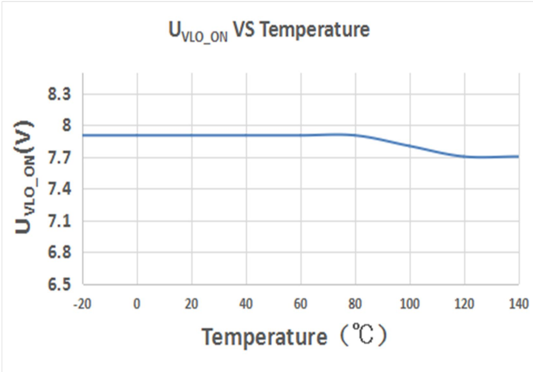
	adjustable output OVP					
$T_{d\text{-}output\_ovp}$	Output OVP debounce time			3		Cycles

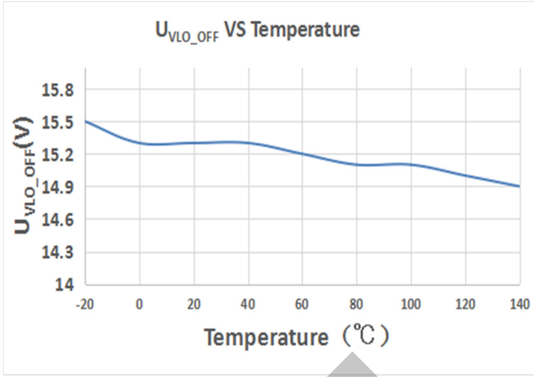
MOSFET SECTION

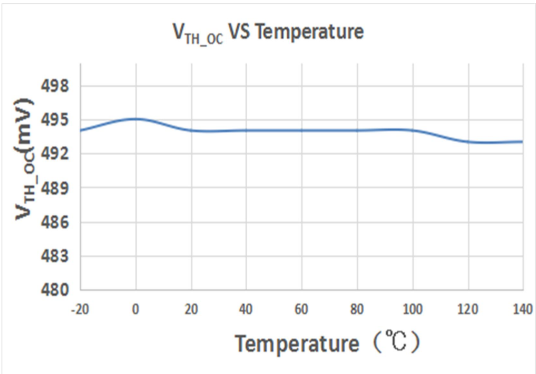
Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
G1138P-S						
BVdss	Mosfet Drain-Source Breakdown Voltage	I_D=250uA	650			V
Rdson	Static drain to source on resistance	V_{GS}=10V，I_D=2A		2		Ω
$I_{D1(DC)}$	Continuous Drain Current	T_C=25℃		4		A
$I_{D2(DC)}$	Continuous Drain Current	T_C=100℃		2.5		A
$I_{DM(pluse)}$	Pulsed Drain Current			16		A

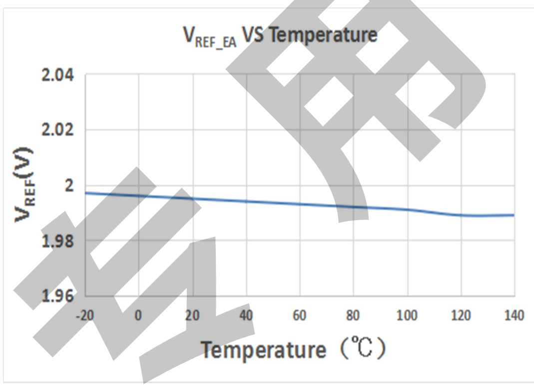
Note:These parameters are not 100% tested, guaranteed by design and characterization.

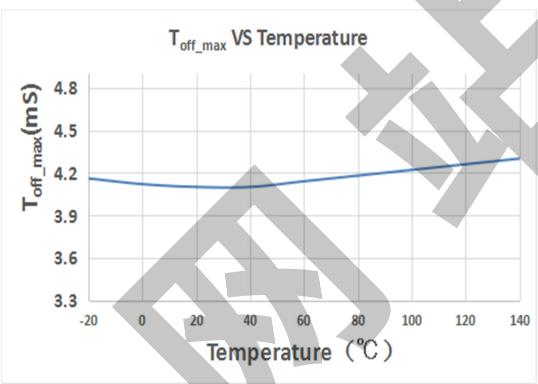
5. CHARACTERIZATION

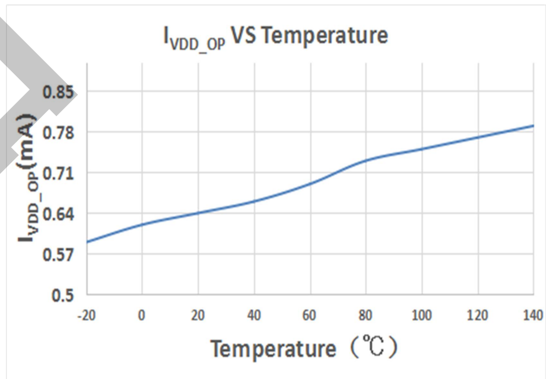












6. OPERATION DESCRIPTION

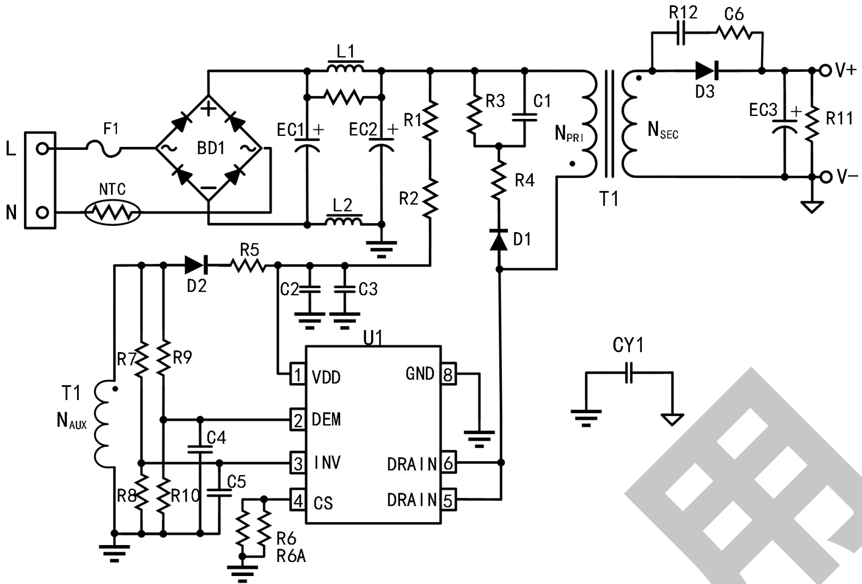


Fig.4. G1138P-S Typical Application

G1138P-S is a cost effective PWM power switch optimized for off-line low power AC-DC applications including battery chargers and adapters. It operates in primary side sensing and regulation, thus opto-coupler and TL431 are not required. Proprietary built-in CV and CC control can achieve high precision CC/CV control meeting most adapter and charger application requirements.

6.1 Startup Current and Operating Current

Startup current of G1138P-S is designed to be very low so that VDD could be charged up above UVLO threshold and starts up quickly. A large value startup resistor can therefore be used to minimize the power loss in application. The Operating current of G1138P-S is as low as 0.7mA. Good efficiency is achieved with the low operating current together with Multi-mode control features.

6.2 Soft Drive

G1138P-S soft drive optimizes system EMI performance. Internal GATE pin have 16V high-level clamp circuits to prevent Gate damage during VDD high-voltage input.

6.3 CC/CV Operation

G1138P-S is designed to produce good CC/CV control characteristic as shown in the Fig.1. In charger applications, a discharged battery charging starts in the CC portion of the curve until it is nearly full charged and smoothly switches to operate in CV portion of the curve.

In an AC/DC adapter, the normal operation occurs only on the CV portion of the curve. The CC portion provides output current limiting. In CV operation, the output voltage is regulated through the primary side control. In CC operation mode, G1138P-S will regulate the output current constant regardless of the output voltage drop.

6.4 Principle of Operation

To support G1138P-S proprietary CC/CV control, system needs to be designed in DCM mode for flyback system (Refer to Fig.4). In the DCM flyback converter, the output voltage can be sensed via the auxiliary winding. During MOSFET turn-on time, the load current is supplied from the output filter capacitor C_O. The current in the primary winding ramps up. When MOSFET turns off, the primary current transfers to the secondary at the amplitude of

$$I_{PKS} = \frac{N_P}{N_S} I_{PK} \qquad (1)$$

The auxiliary voltage reflects the output voltage as shown in fig.5 and it is given by

$$V_{aux} = \frac{N_{aux}}{N_S} * (V_{out} + V_f) \qquad (2)$$

Where Vf indicates the drop voltage of the output Diode.

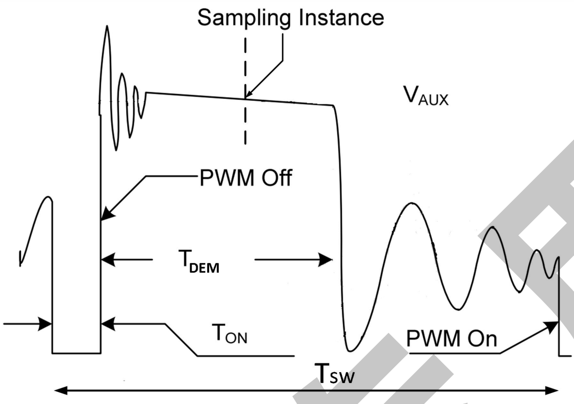


Fig.5. Auxiliary voltage waveform

Via a resistor divider connected between the auxiliary winding and INV pin, the auxiliary voltage is sampled at the end of the demagnetization and it is hold until the next sampling. The sampled voltage is compared with V_{REF_EA} (2.0V) and the error is amplified. The error amplifier output reflects the load condition, controls the PWM switching frequency and duty cycle to regulate the output voltage, thus constant output voltage can be achieved. When sampled voltage is below V_{REF} and the error amplifier output reaches its maximum, the switching frequency is controlled by the sampled voltage thus the output voltage to regulate the output current, thus the constant output current can be achieved.

6.5 Constant current control

The G1138P-S can realize high precision constant current output control By using the timing relation between INV pin voltage and CS pin voltage. As shown in the figure. 6. in the constant voltage output mode, when the output power of the system increases and approaches the constant current output control point, the main inductance current reaches the maximum value.

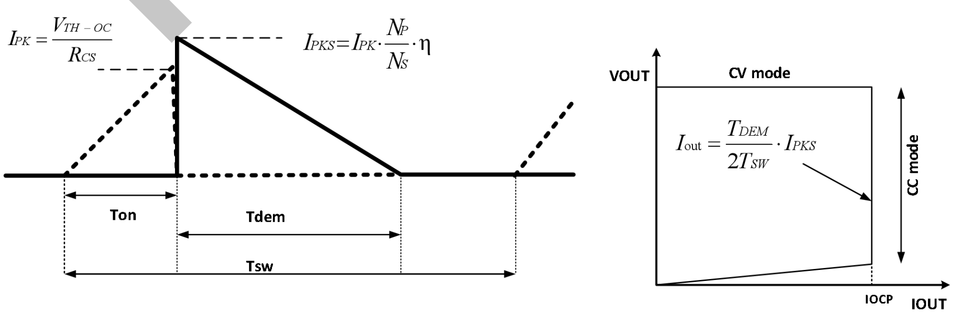


Fig.6. constant current

As shown in figure. 6. , the primary inductor current, transformer turn ratio, Tdem and Tsw determine the average output current of the secondary side. If the leakage inductance is ignored, the equation for the average output current of the secondary side is shown in Fig. 6. When the output current reaches the output reference of the primary side constant current control module, the IC will enter the FM mode, no matter how the output voltage is lower than the constant voltage output standard or exactly, as long as the VDD voltage is not lower than its U_{VLO_ON} voltage , the IC will continue to work.

the ratio of Tdem to Tsw is strictly controlled to 1/2 in constant current output mode, so the actual average output current can be expressed as:

$$I_{out} = \frac{1}{4}\frac{V_{TH-OC} \cdot N_P * \eta}{R_{CS} \cdot N_S} \qquad (3)$$

η:Transformer conversion efficiency.
Rcs:Sampling Resistance between MOSFET S Pole and GND.

6.6 Adjustable CC point and Output Power

In G1138P-S, the CC point and maximum output power can be externally adjusted by external current sense resistor R_S at CS pin as illustrated in Typical Application Diagram. The output power is adjusted through CC point change. The larger R_S, the smaller CC point is, and the smaller output power becomes, and vice versa as shown in Fig.7.

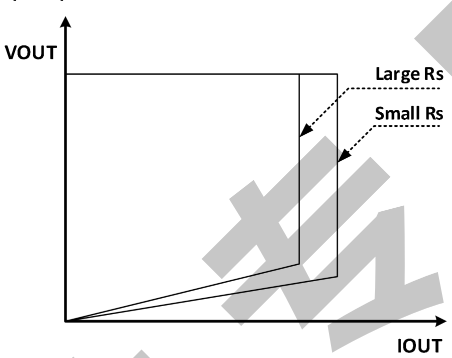


Fig.7. Adjustable output power by changing R_S

6.7 Multi-mode constant voltage operation

As shown in figure 8, in order to meet the demanding requirements of average efficiency and standby power consumption, the G1138P-S uses a combination of PFM control (FM) and PAM control (AM).

When the output is close to full load, the system works in FM mode, Between light and full load condition, the system works in AM mode and FM mode. When the system is close to no-load output, the system works in FM mode to reduce standby power consumption. With this control technology, the system can obtain standby power consumption lower than that of 70mW.

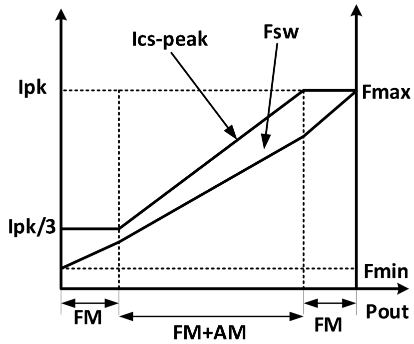


Fig.8. FM mode and AM mode

6.8 Operation switching frequency

The switching frequency of G1138P-S is adaptively controlled according to the load conditions and the operation modes. No external frequency setting components are required. The operation switching frequency at maximum output power is recommended to 90 KHz internally.

For flyback operating in DCM, The maximum output power is given by

$$P_{outmax} = P_{inmax}\eta = \frac{1}{2} \cdot L_P \cdot f_{sw} \cdot I_{PK}^2 \cdot \eta \qquad (4)$$

Where L_P indicates the inductance of primary winding, I_{PK} is the peak current of primary winding and η is System conversion efficiency . Refer to the equation 4, the change of the primary winding inductance results in the change of the maximum output power and the constant output current in CC mode. To compensate the change from variations of primary winding inductance, the switching frequency is locked by an internal loop such that the switching frequency is

$$f_{sw} = \frac{1}{2 \cdot T_{DEM}} \qquad (5)$$

Since T_{DEM} is inversely proportional to the inductance, as a result, the product L_P and f_{SW} is constant, thus the maximum output power and constant current in CC mode will not change as primary winding inductance changes. Up to +/-10% variation of the primary winding inductance can be compensated.

6.9 Current Sensing and Leading Edge Blanking

Cycle-by-Cycle current limiting is offered in G1138P-S current mode PWM control. The switch current is detected by a sense resistor into the CS pin. An internal leading edge blanking circuit chops off the sensed voltage spike at initial internal power MOSFET on state so that the external RC filtering on sense input is no longer needed. The PWM duty cycle is determined by the current sense input voltage and the error amplifier output voltage.

6.10 Programmable Cable drop Compensation

In G1138P-S,Cable drop compensation is implemented to achieve good load regulation.An offset voltage is generated at INV pin by an internal current flowing into the resister divider.the current is proportional to the switching off time,as a result,it is inversely proportional to the output load current,thus the drop due to the cable loss can be compensated.As the load current decreases from full-load to no-load,the offset voltage at INV will increase.It can also be programmed by adjusting the resisitance of the divider to compensate the drop for various cable lines used.

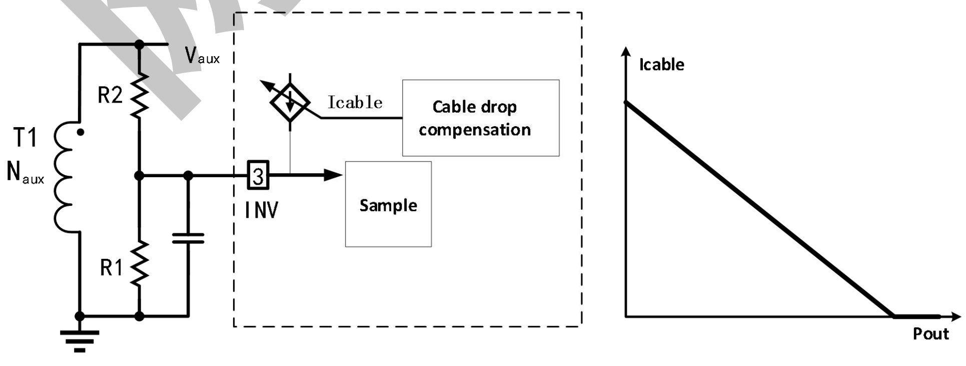


Fig.9. Cable drop compensation

The actual compensation can be adjusted by adjusting the divider resistance values of R1 and R2. The percentage of maximum compensation is

$$\frac{\triangle \text{V cable}}{\text{Vout}} \approx \frac{I\text{cable-max}\,(R1 // R2)}{V_{\text{REF\_EA}}} \times 100\% \qquad (6)$$

For example:R1=3K,R2=20K,then:

$$\frac{\triangle \text{V cable}}{\text{Vout}} \approx \frac{50\text{uA}\,(3K // 20K)}{2} \times 100\% = 6.5\%$$

6.11 Output OVP

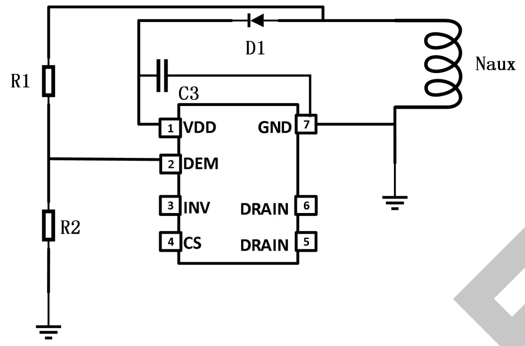


Fig.10. DEN pin Application schematic

For output OVP detection,when Gate is off,V_{DEM} is equal to Vaux*R2/(R1+R2).If V_{DEM} is larger than 3V（typical）,OVP auto-recovery protection is triggered after 3 Gate cycles debounce.By selecting proper R1 and R2 resistance,output OVP level can level can be programmed.

$$V\text{ovp} \approx \frac{V\text{aux} \times N\text{s}}{\text{Naux}} = \frac{[3 \times (R1 + R2) / R2] \times N\text{s}}{N\text{aux}} \qquad (7)$$

Ns:Secondary winding turns.
Naux:auxiliary winding turns.

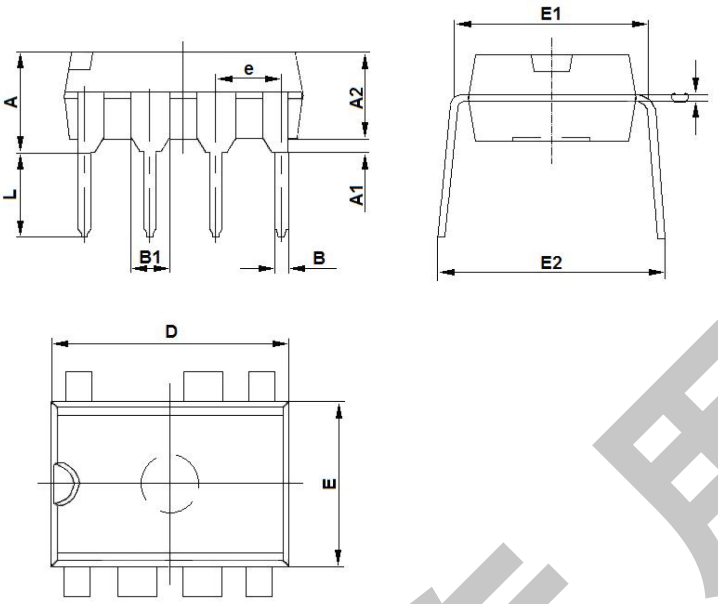
When the function of output OVP is not used,R2 need to set a resistor,R1 do not need to set resistor.The value of R1 is recommended to 510Ω.

6.12 Protection

Good power supply system reliability is achieved with its rich protection features including Cycle-by-Cycle current limiting (OCP), VDD OVP,Under Voltage Lockout on VDD (UVLO),Output short circuit protection,Over-temperature protection(OTP),Output overvoltage undervoltage protection and so on.These protection functions can be automatically restored without the need to restart.

7. Package Information

DIP7:



Symbol	Dimension in Millimeters		Dimensions in Inches	
	Min	Max	Min	Max
A	3.710	5.334	0.146	0.210
A1	0.381		0.015	
A2	2.921	4.953	0.115	0.195
B	0.350	0.650	0.014	0.026
B1	1.524(BSC)		0.06(BSC)	
C	0.200	0.360	0.008	0.014
D	9.000	10.16	0.354	0.400
E	6.096	7.112	0.240	0.280
E1	7.320	8.255	0.288	0.325
e	2.540(BSC)		0.1(BSC)	
L	2.921	3.810	0.115	0.150
E2	7.620	10.92	0.300	0.430

IMPORTANT NOTICE

Data and specifications subject to change without notice.
This product has been designed and qualified for Industrial Level and Lead-Free.
Qualification Standards can be found on GS's Web site.
Global Semiconductor HEADQUARTERS:
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