QR-Mode PWM Converter with Wide VCC Operation Range

Features

- Built-in 650V GaN Power MOSFET
- Low Start-Up Current
- Wide VCC Operation Range up to 85V
- Soft Driving to Reduce EMI
- Multi-Mode Operation (QR/DCM/Burst)
  - QR Operation @ Full/Medium Load
  - DCM Operation @ Light Load
  - Burst Mode at No Load
- Switching Frequency up to 160KHz
- 8ms Soft-Start
- Over Current Protection (OCP)
- Over Load Protection (OLP)
- Short Circuit Protection (SCP)
- Brown in/out on ZCD Pin
- Over Voltage Protection on VCC Pin
- Output Over Voltage Detection on ZCD Pin
- Output Diode Short Circuit Protection (ODSP)
- On Chip OTP Protection
- ESOP-7 Package

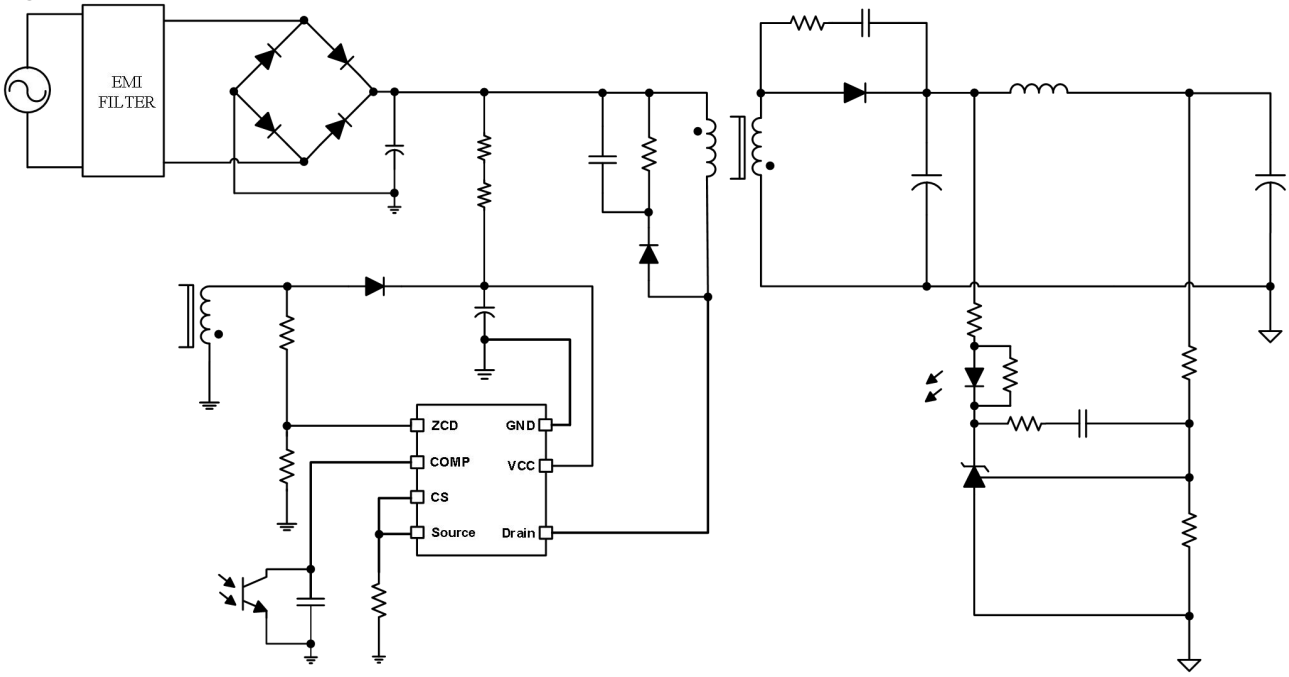
Description

GN9238 is a high performance multi-mode (QR/DCM/Burst) operation PWM switcher for application on flyback converter. It could turn standby mode to green mode for high switching efficiency. It provides several functions of low startup current, over current protection, over voltage protection, short circuit protection, output diode short circuit protection, and internal OTP to prevent the circuit being damaged.

Application

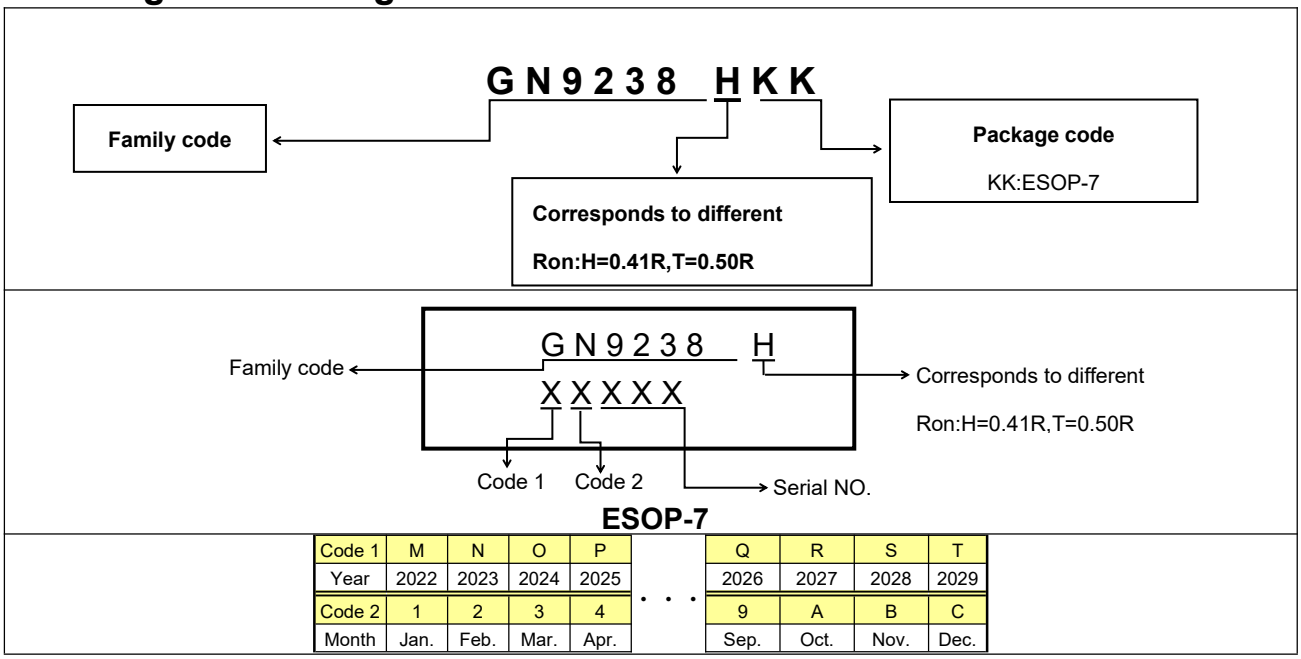
- PD+QC Charger
- Switching Mode Power Supply

Typical Application Information



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Ordering and Marking Information



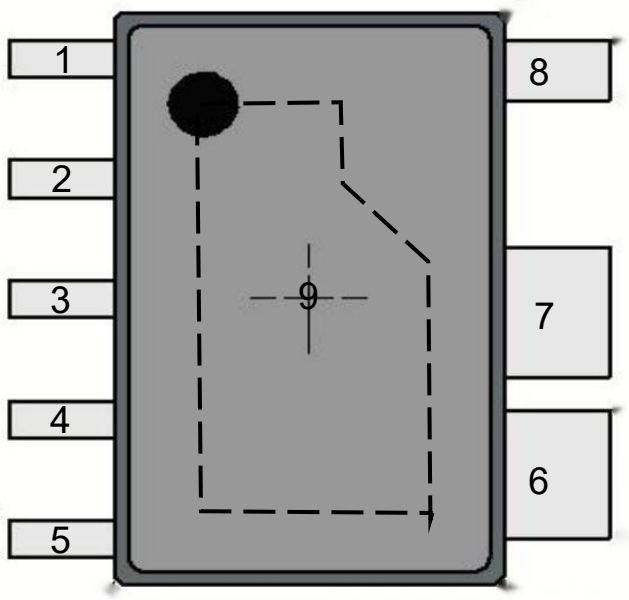
Code 1	M	N	O	P	. . .	Q	R	S	T
Year	2022	2023	2024	2025		2026	2027	2028	2029
Code 2	1	2	3	4		9	A	B	C
Month	Jan.	Feb.	Mar.	Apr.		Sep.	Oct.	Nov.	Dec.

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Pin Configuration

ESOP-7 (TOP VIEW)



Pin Description

Pin No.	Name	Function
1	SOURCE	Source of power MOSFET
2	NC	Not connected
3	COMP	Voltage feedback pin, by connecting a photo-coupler to control the duty cycle
4	ZCD	This pin is for quasi-resonant detection, OVP and Brown in/out functions
5	VCC	Power supply pin
6, 7	GND	Ground reference pin
8	DRAIN	Drain of power MOSFET

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Absolute Maximum Ratings

Supply voltage VCC ---------- 100V

DRAIN ---------- 650V

COMP, SOURCE, ZCD, CS ---------- -0.3~6.0V

Junction temperature ---------- 150℃

Storage temperature range ---------- -65℃ ~ 150 ℃

ESOP-7 package thermal resistance (θ_{JA}) *1---------- 31.4 ℃/W

Power dissipation (ESOP-7, at ambient temperature 85℃) ---------- 1270 mW

Lead temperature (ESOP-7, soldering, 10 sec) ---------- 230℃

Lead temperature (All Pb free packages, soldering, 10 sec) ---------- 260℃

ESD, human body model ---------- 2.5KV

ESD, machine model ---------- 250V

Caution: The “Absolute Maximum Ratings” are those values beyond which the safety of the device cannot be guaranteed and may cause permanent damage to the IC. These are stress ratings only and functional operation of the device at these or any other condition beyond those indicated in the Electrical Characteristics section of the specification is not implied. The “Electrical Characteristics” table defines the conditions for actual device operation. Exposure to absolute maximum rated conditions for extended periods may affect device reliability.

*1: The thermal resistance is tested under 1in^2 FR4 PCB covered with more than 90% copper on two sides.

Recommended Operating Conditions

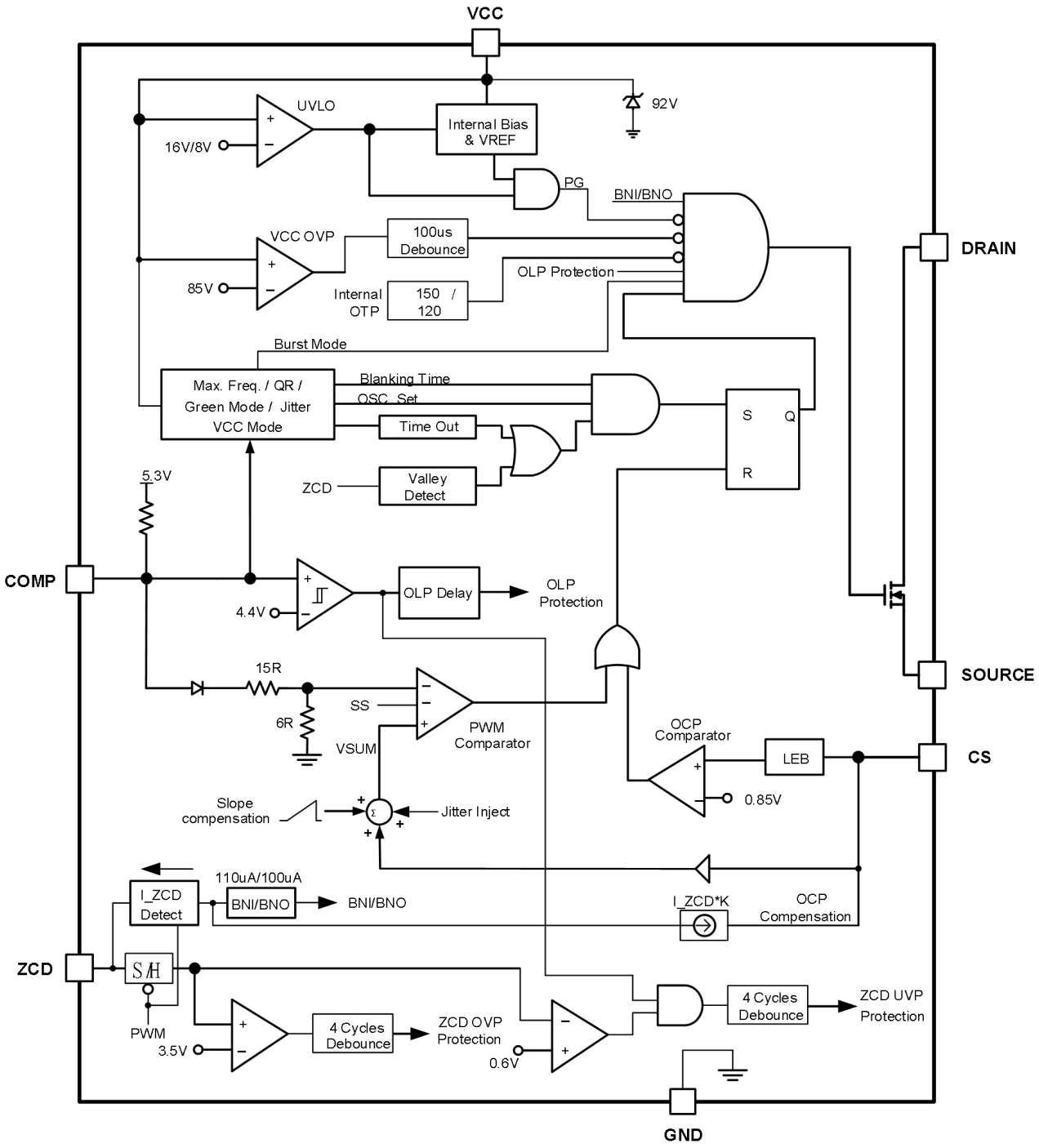
Item	Min.	Max.	Unit
Operating Junction temperature	-40	125	℃
Operating ambient temperature	-40	85	℃
Start Up Resistor (DC bus side)	3M	4.7M	Ω
Supply voltage VCC	9.5	82	V
VCC Capacitor	2.2	10	μF
COMP pin paralleling capacitor	0.1	10	nF

Note:

- Not to exceed the maximum junction temperature of the IC, this relates to the operating power of the IC and the thermal resistance of the IC-package as above.
- The small signal components should be placed to close the IC pin as possible.
- An electrolytic capacitor or 1206 SMD ceramic capacitor is recommend for VCC-GND power supply filter.
- It’s essential to connect VCC pin with a SMD ceramic capacitor (0.1μF~0.47μF) to filter out the undesired switching noise for stable operation.
- Connecting a capacitor to COMP pin is also essential to filter out the undesired switching noise for stable operation.

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Block Diagram



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Electrical Characteristics (VCC = 15.0V & T_A = +25℃, unless otherwise stated.)

Parameter		Min.	Typ.	Max.	Unit
SUPPLY VOLTAGE (VCC Pin)					
Startup current VCC=UVLO ON-0.1V			5	10	uA
Operating current (with 1nF load on OUT pin), Vcomp = 0V			0.6		mA
Operating current (with 1nF load on OUT pin), Vcomp = 2.5V			3		mA
Operating current (with 1nF load on OUT pin), protection tripped (VCC OVP, OLP, ZCD OVP/UVP)			1		mA
UVLO-OFF			8		V
UVLO-ON			16		V
VCC Mode entry point			8.5		V
VCC Mode hysteresis			0.5		V
OVP trig level			85		V
OVP debounce time*			100		μS
Clamp Voltage (I_{VCC}=3mA)			92		V
VOLTAGE FEEDBACK (COMP Pin)					
Short circuit current, Vcomp = 0V			200		uA
Open loop voltage, COMP pin open			5.3		V
Green Mode start voltage			3.6		V
Green Mode end voltage			1.9		V
Burst Mode voltage			1.0		V
Burst Mode hysteresis			100		mV
OLP trip level, Vcomp			4.4		V
OLP delay time			50		ms
CURRENT SENSING (SOURCE Pin)					
Maximum input voltage,VCS (OFF)			0.85		V
Leading-edge blanking time			300		nS
Input impedance		1			MΩ
Delay to output*			100		nS
The protection level of output diode short circuit			0.95		V
De-bounce time of output diode short circuit protection			4		Pulse

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Electrical Characteristics (VCC = 15.0V & TA = +25℃, unless otherwise stated.)

Parameter		Min.	Typ.	Max.	Unit
ZCD (ZCD Pin)					
Upper clamp level, IZCD=1mA			4.6		V
Lower clamp level, IZCD=-1mA			-0.5		V
ZCD blanking time*			2.5		μs
ZCD OVP			3.5		V
OVP de-bounce time*			4		cycle
ZCD UVP			0.6		V
UVP de-bounce time*			4		cycle
Brown in tripped level			110		uA
Brown out tripped level			100		uA
Brown out de-bounce time			72		mS
OSCILLATOR					
QR max. frequency			160		kHz
Green mode frequency			22		kHz
Jitter frequency (CCM Mode)			±6		%
Soft Start Time (SOURCE Pin)					
Soft Start Time*			8		ms
GATE DRIVER OUTPUT (OUT Pin)					
Output low level, VCC = 18V, Io = 20mA				1	V
Output high level, VCC = 18V, Io = 20mA		8			V
Rising time, load capacitance = 1000pF*			250		ns
Falling time, load capacitance = 1000pF*			20		ns
VGATE clamp voltage (VCC = 25V)			12		V
Internal OTP (Guaranteed by Design)					
OTP*			150		℃
Hysteresis*			30		℃
GaN Power MOSFET SECTION					
BVdss, Vgs=0V		650			V
Static Rdson, Vg=10V	GN9238HKK		0.41		Ω
	GN9238TKK		0.50		Ω

*Guaranteed by Design.

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Typical Performance Characteristics

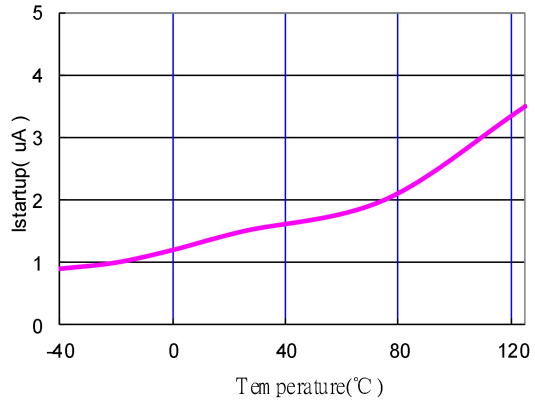


Fig. 1 Istartup current vs. Temperature

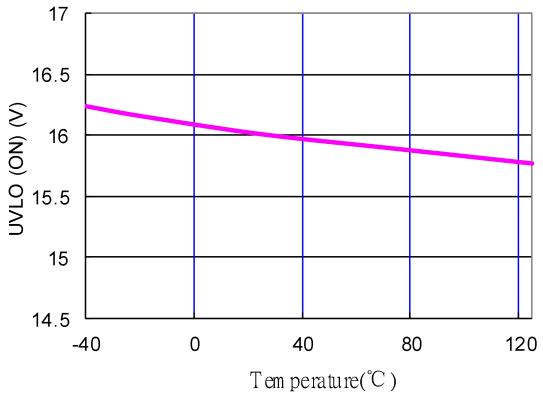


Fig. 2 UVLO (ON) vs. Temperature

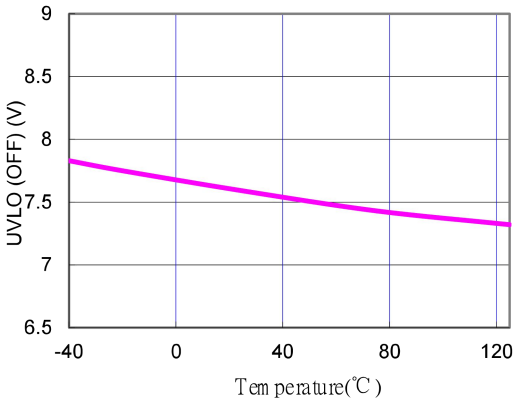


Fig. 3 UVLO (OFF) vs. Temperature

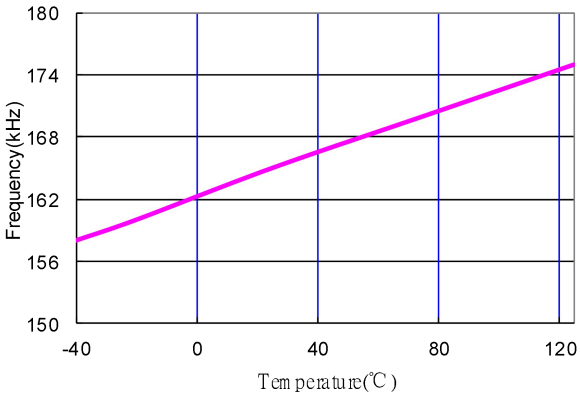


Fig. 4 Max. Frequency vs. Temperature

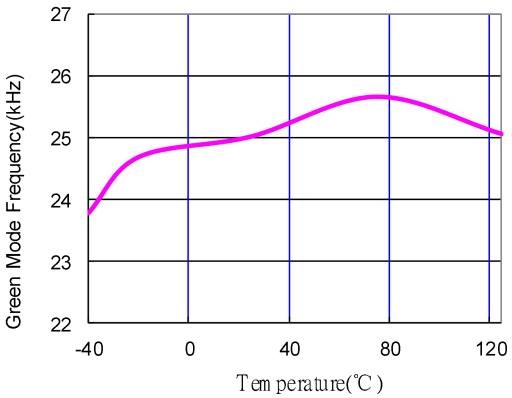


Fig. 5 Green Mode Frequency vs. Temperature

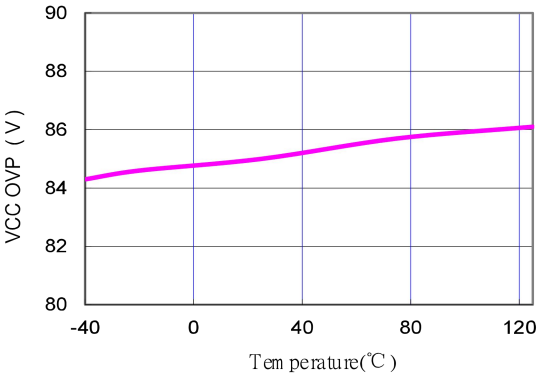


Fig. 6 VCC OVP vs. Temperature

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Application Information

Overview

GN9238 is a high performance multi-mode (QR/DCM/Burst) operation PWM switcher for application on flyback converter. This results in a low-cost solution for low power AC/DC adapters. It integrated more functions to reduce the external components counts and the size. Its major features are described as below.

Start-up Current

The typical start-up current is 5uA. Very low start-up current allows the PWM controller to increase the value of start-up resistor and then reduce the power dissipation on it.

Under-voltage Lockout (UVLO)

A hysteresis UVLO comparator is implemented in GN9238 series, then the turn-on and turn-off thresholds level are fixed at 16V and 8V respectively. This hysteresis ensures that the start-up capacitor will be adequate to supply the chip during the start-up period. The startup operation is show in Fig. 7.

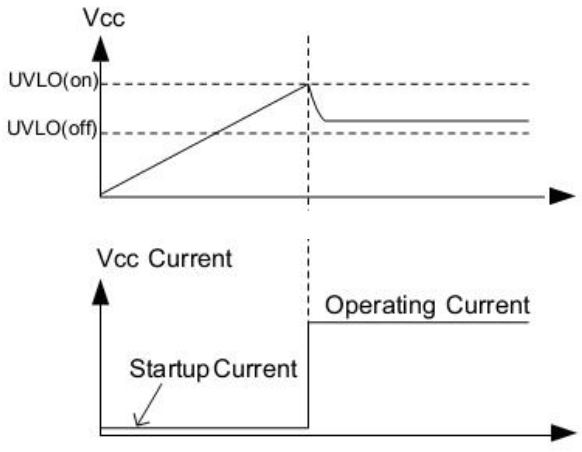


Fig.7

Multi-Mode Operation

GN9238 is a multi-mode (QR/DCM/Burst) operation controller. The operation of GN9238 is changed by switching frequency depends on comp pin voltage, as show in Fig.8. At heavy load, it operates on QR mode. At medium load, it operates on skip - valley QR mode. That is, when the load decrease, the system will automatically skips multi-wave valley for decreasing the switching frequency. And, when Vcomp is lower than burst mode voltage, the output of gate driver of GN9238 will be shut down for reinforcement Green Energy-Saving.

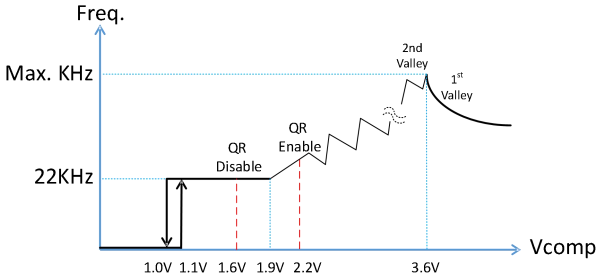


Fig.8

Quasi-Resonant Detection

ZCD pin detects leak of transformer and resonance of parasitic capacitance of MOSFET and turn on MOSFET at nearby trough of wave of resonance to reduce the power loss and improve the conversion efficiency.

Leading-edge Blanking (LEB)

Each time the power MOSFET is switched on, a turn-on spike will inevitably occur at the sense resistor. To avoid fault trigger, a leading-edge blanking time is built in. During this blanking period, the current-limit comparator is disabled and cannot switch off the gate driver.

Over-Voltage Protection (OVP) on VCC - Auto Recovery mode

Over-voltage Protection is implemented in GN9238 for being damaged from abnormal condition. When VCC voltage is higher than the OVP trig level, the Output of Gate driver will be shut down. VCC OVP is auto-recovery mode. Once the condition of over voltage happened, the Gate driver will be shut down until the next VCC UVLO-ON. This operation is a Hiccup mode as shown in Fig.9

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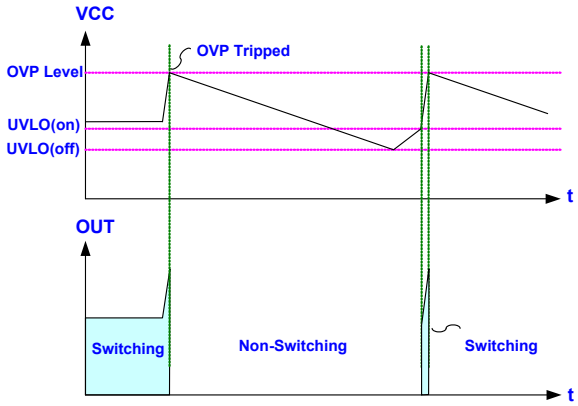


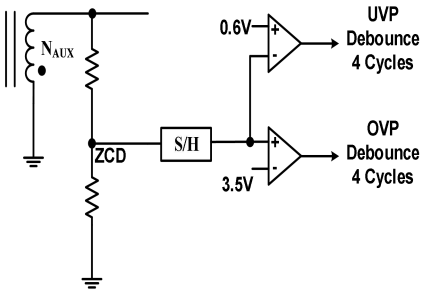
Fig.9

Output OVP on ZCD - Auto Recovery mode

An output over voltage protection is implemented in the GN9238. As shown in Fig.10, It senses the auxiliary voltage via the divided resistors. The over voltage protection works by sampling the plateau voltage after a delay time. The sampling voltage is compared with a threshold voltage 3.5V. If the sampling voltage exceeds the ZCD OVP trip level, the GN9238 will switch the power MOSFET off. The ZCD OVP function is an auto-recovery type protection.

Output Under-voltage Protection (UVP) on ZCD– Auto Recovery mode

To protect the circuit from damage due to output short condition, an auto-recovery type of UVP protection is implemented for it. If the ZCD voltage declines below 0.6V for over 4 cycles, the protection will be activated to turn off the gate until the next VCC UVLO-ON.



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Fig.10

Brown-In/Brown-Out Protection- Auto Recovery mode

GN9238 has the Brown-in/Brown-out function. This function is detected by internal circuit on ZCD pin as show in Fig.11. After the AC power on, If laux > IBNI the BNI protection is triggered and the PWM starts to work. The BNI de-bounce time is 2~5 PWM pulses. During the BNI mode, If laux < IBNO, the BNO protection is triggered and the PWM stops to work. The brown in and brown out entry AC voltage is decided as follows:

$$Vac_BNI = \frac{Np}{Naux} * Ibni * R1 * \frac{1}{\sqrt{2}}$$

$$Vac_BNO = \frac{Np}{Naux} * Ibno * R1 * \frac{1}{\sqrt{2}}$$

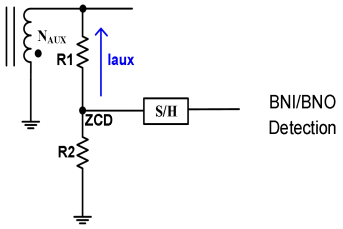


Fig.11

Adjustable High/Low Line OCP Compensation

In order to get the consistency of the output over current protection trig point for the input AC voltage range that should compensate the trig point of the OCP value. The compensation value is proportional to the input AC voltage. When power MOSFET at turn on period the current drawn from ZCD pin is proportional to the input AC voltage. In the meantime the OCP compensation current flows through the CS pin internal built-in filter resistor (around 1.5K Ohm) then makes the compensation voltage △Vcs offset. The I_{OCP} is around $0.5*I_{ZCD}$. The compensation mechanism is shown in Fig.12.

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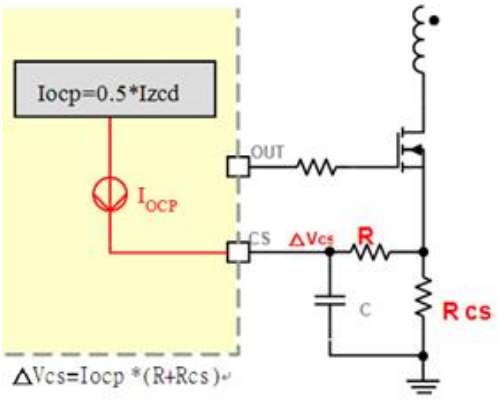


Fig.12

Gate Clamp/Soft Driving

Driver output is clamped by an internal 12V clamping circuit to prevent from undesired over-voltage gate signals. And under the conditions listed below, the gate output will turn off immediately to protect the power circuit.

- OCP
- SCP
- OVP
- OLP
- ODSP
- Brown out

The GN9238 also has soft driving function to minimize EMI.

VCC Mode

In order to avoid the output voltage shut down by load changing from full to no load, GN9238 is built-in the VCC mode function. When the load from full changes to no load, the output voltage will overshoot and pull low the COMP pin by feedback loop (Into burst mode). Thus the PWM duty will disappear and no power delivers to the secondary. If there is without any mechanism to prevent this situation, the VCC pin voltage will down to UVLO off and the IC will re-start again. The VCC Mode operation is shown in Fig. 13.

The VCC mode function is used to prevent the output re-start again when load changes. So never let the system operate on the VCC mode at no load. The system should be designed to operate on the burst mode, otherwise the input power maybe become larger.

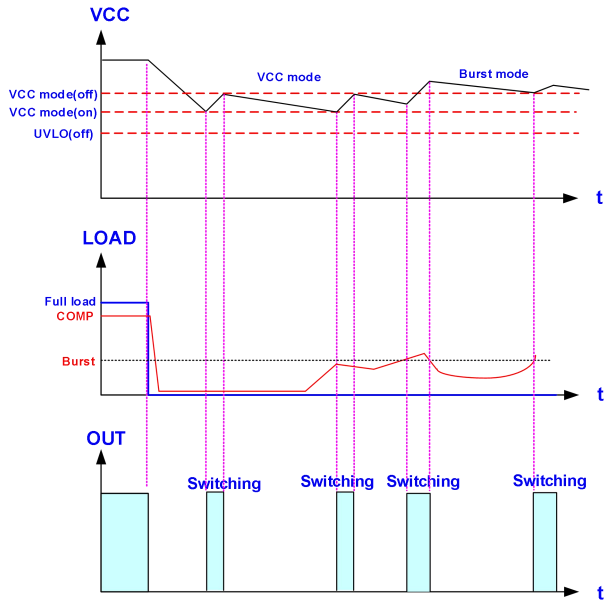
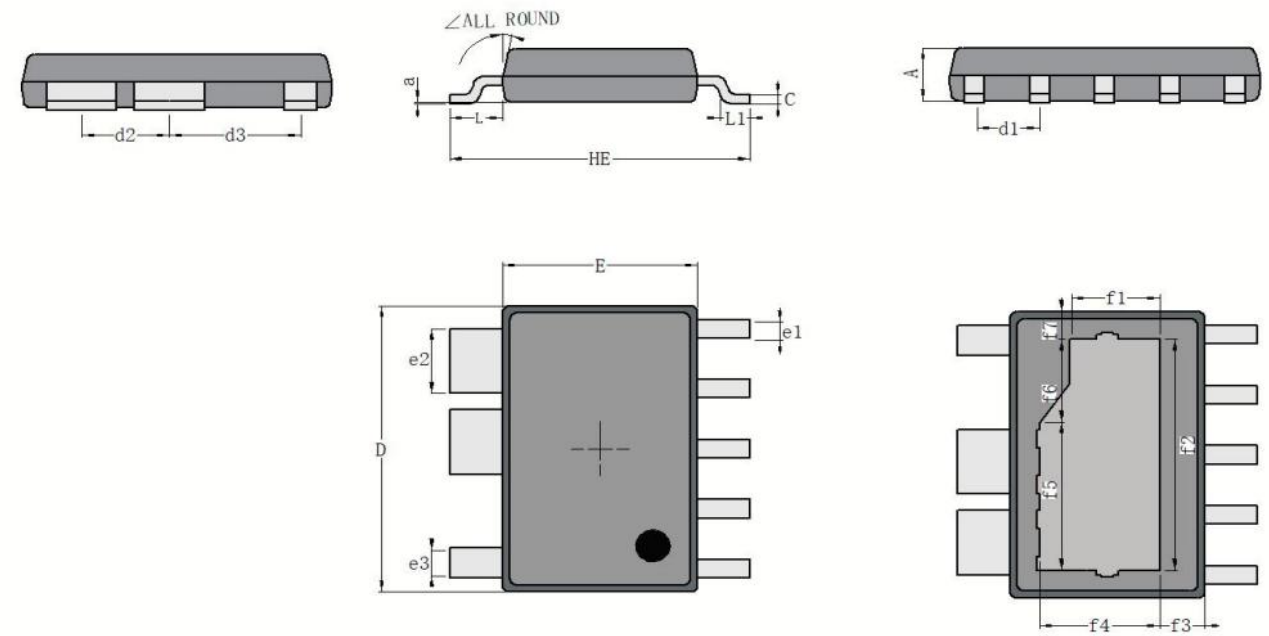


Fig.13

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Package Information

ESOP-7



Unit		A	C	D	E	HE	d1	d2	d3	e1	e2	e3	L	L1	f1	f2	f3	f4	f5	f6	f7	a	∠
mm	max	1.25	0.25	6.40	4.10	6.10	1.35	1.80	2.68	0.45	1.45	0.70	1.15	0.80	1.85	5.05	0.95	2.45	3.26	1.84	0.65	0.2 (ref)	12°
	typ	1.15	0.20	6.20	3.90	6.00	1.30	1.75	2.63	0.40	1.40	0.65	1.05	/	1.80	5.00	0.90	2.40	3.21	1.79	0.60		
	min	1.05	0.15	6.00	3.70	5.90	1.25	1.70	2.58	0.35	1.35	0.60	0.95	0.40	1.75	4.95	0.85	2.35	3.16	1.74	0.55		
mil	max	49	10	252	161	240	53	71	106	18	57	28	45	31	73	199	37	96	128	72	26	8 (ref)	
	typ	45	8	244	154	236	51	69	104	16	55	26	41	/	71	197	35	94	126	70	24		
	min	41	6	236	146	232	49	67	102	14	53	24	37	16	69	195	33	93	124	69	22		

Application	Carrier Width	Devices Per Reel
ESOP- 7	13	5000

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