

## QR-Mode Flyback Converter with Integrated Protections

### Features

- Internal 650V S.J. MOSFET
- Low Start-Up Current
- 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 is 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
- Over Voltage Protection on ZCD Pin
- On Chip OTP Protection
- ESOP6 Package

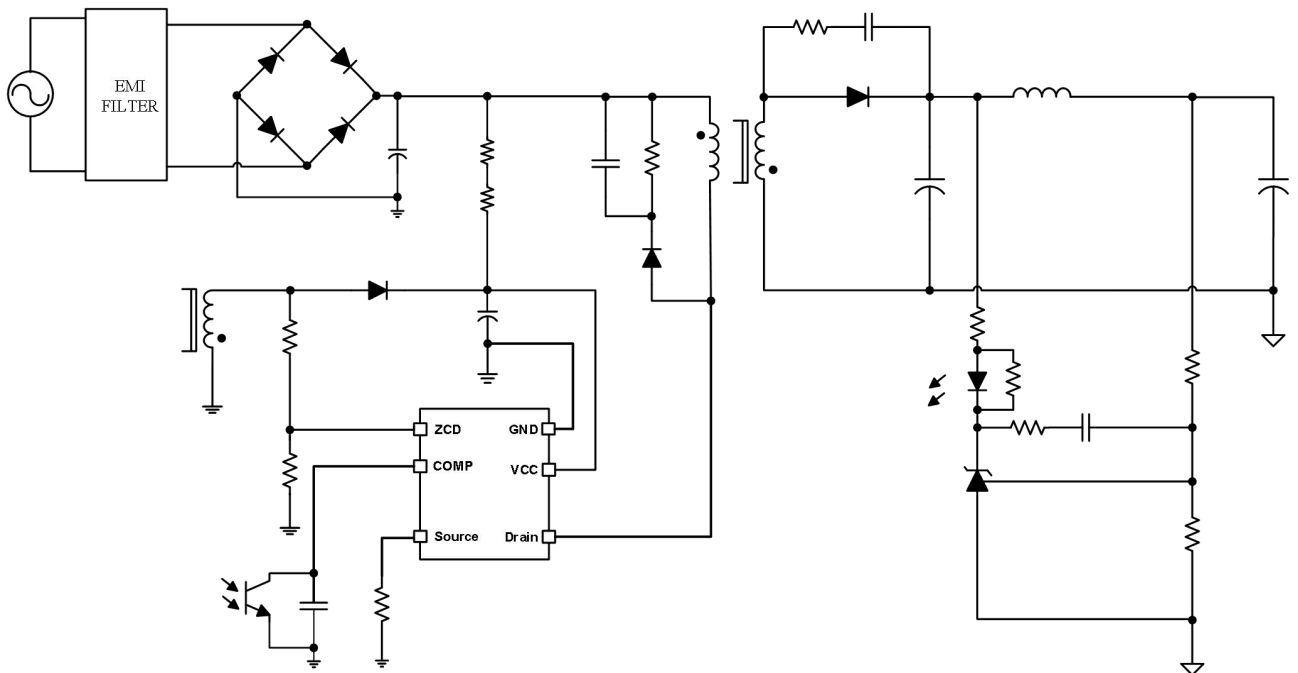
### Description

GR9235Q is integrated a high performance multi-mode (QR/DCM/Burst) PWM converter and a 650V super junction MOSFET. It could turn standby mode to green mode for high switching efficiency. It provides functions of low startup current, over current protection, over voltage protection, short circuit protection, brown in/out protection, and internal OTP to prevent the circuit being damaged.

### Application

- PD+QC Charger
- Switching Mode Power Supply

### Typical Application Information



## Ordering and Marking Information

**GR9235QX**

**Family Code**

**Package Code**

KG : ESOP 6

**RoHS Code**

G : Green (Halogen Free) Device  
L : PB Free Device

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**ESOP-6**

GR9235QX  
XXXXX

Series with different Ron:  
A:0.57R,X:1.0R,W:1.5R

Code 1

Code 2

Serial No.

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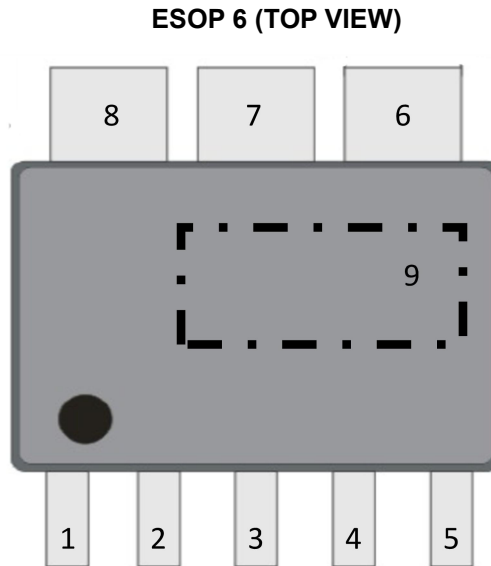
Code 1	M	N	O	P		Q	R	S	T
Year	2022	2023	2024	2025	...	2026	2027	2028	2029
Code 2	1	2	3	4		9	A	B	C
Month	Jan.	Feb.	Mar.	Apr.		Sep.	Oct.	Nov.	Dec.

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## Pin Configuration



## Pin Description

Pin No.	Name	Function
1	GND	Ground reference pin
2	VCC	Power supply pin
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	SOURCE	Source of power MOSFET
6, 7, 8, 9	DRAIN	Drain of power MOSFET

## Absolute Maximum Ratings

Supply voltage VCC	30V
DRAIN	650V
COMP, CS, ZCD, SOURCE	-0.3~6.0V
Junction temperature	150°C
Storage temperature range	-65°C ~ 150 °C
ESOP 6 package thermal resistance	2.4°C/W
Power dissipation (ESOP 6, at ambient temperature 85°C)	250mW
Lead temperature (ESOP 6 , soldering, 10 sec)	230°C
Lead temperature (All Pb free packages, soldering, 10 sec)	260°C
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.

## Recommended Operating Conditions

Item	Min.	Max.	Unit
Operating Junction temperature	-40	125	°C
Operating ambient temperature	-40	85	°C
Start Up Resistor (DC bus side)	3M	4.7M	Ω
Supply voltage VCC	10	26	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 close to IC pin as possible.
- An electrolytic capacitor or 1206 SMD ceramic capacitor is recommend for VCC-GND to avoid noise of resonance.
- 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.

**Electrical Characteristics** (TA = +25°C unless otherwise stated, VCC = 15.0V)

Parameter	Min.	Typ.	Max.	Unit
<b>SUPPLY VOLTAGE (VCC Pin)</b>				
Startup current VCC=UVLO ON-0.1V		2	5	uA
Operating current (with 1nF load on OUT pin), Vcomp = 0V	0.7	1.0	1.3	mA
Operating current (with 1nF load on OUT pin), Vcomp = 2.5V		5		mA
Operating current (with 1nF load on OUT pin), protection tripped (VCC OVP, OLP, ZCD OVP/UVLP)	0.8	1.0	1.2	mA
UVLO-OFF	7	8	9	V
UVLO-ON	15	16.0	17	V
VCC Mode Entry Point		8.5		V
VCC Mode Hysteresis		0.5		V
OVP level on VCC pin	26.5	28	29.5	V
OVP level on VCC pin Debounce Time*		100		μS

**VOLTAGE FEEDBACK (COMP Pin)**

Short circuit current, Vcomp = 0V	150	200	250	uA
Open loop voltage, COMP pin open	4.9	5.3	5.7	V
Green Mode Start voltage		3.6		V
Green Mode end voltage		1.9		V
Burst Mode voltage	0.95	1.0	1.05	V
Hysteresis		100		mV
OLP trip level, Vcomp	4.2	4.4	4.6	V
OLP delay time		60		ms

**CURRENT SENSING (CS Pin)**

Maximum input voltage, VCS(OFF)	0.80	0.85	0.90	V
Leading-edge blanking time		250		nS
Input impedance	1			MΩ
Delay to Output*		100		nS
The protection level of output diode Short circuit		0.9		V
De-bounce time of output diode Short circuit protection		4		Pulse

**Electrical Characteristics** (TA = +25°C unless otherwise stated, VCC = 15.0V)

Parameter	Min.	Typ.	Max.	Unit
<b>ZCD (ZCD Pin)</b>				
Upper Clamp Level, IZCD=1mA	4	4.6	5.2	V
Lower Clamp Level, IZCD=-1mA	-0.8	-0.5		V
ZCD Blanking Time*		2.5		μs
ZCD OVP	3.4	3.5	3.6	V
OVP OVP De-bounce Time*		4		cycle
UVP Level	0.7	0.8	0.9	V
After UVP De-bounce Time		4		cycle
Brown in tripped level	100	110	120	uA
Brown out tripped level	90	100	110	uA
Brown out de-bounce time		72		mS
<b>OSCILLATOR</b>				
QR max. Frequency		160		kHz
Green Mode Frequency	20	22	24	kHz
Jitter Frequency (CCM Mode)		±6		%
<b>Soft Start Time (CS Pin)</b>				
Soft Start Time*	6	8	10	ms
<b>Internal OTP (Guaranteed by Design)</b>				
OTP*		150		°C
Hysteresis*		30		°C
<b>Super junction Device SECTION</b>				
BVdss, Vgs=0V		650		V
Rdson, Vgs=10V	GR9235QA		0.57	Ω
	GR9235QX		1.0	Ω
	GR9235QW		1.5	Ω

\*Guaranteed by Design.

## Typical Performance Characteristics

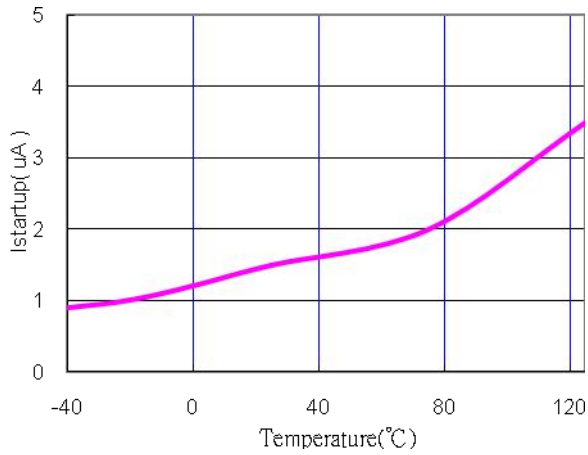


Fig. 1 Istartup current vs. Temperature

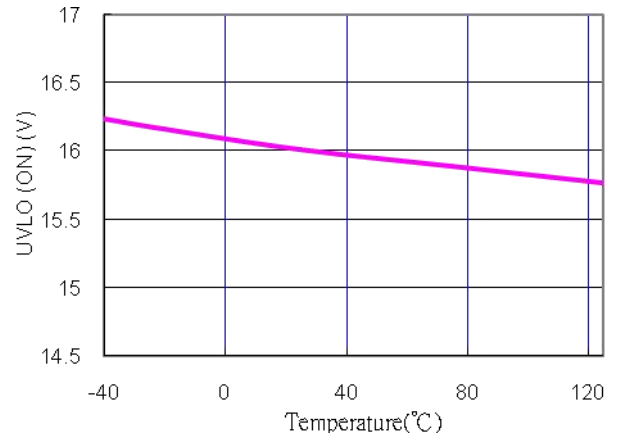


Fig. 2 UVLO (ON) vs. Temperature

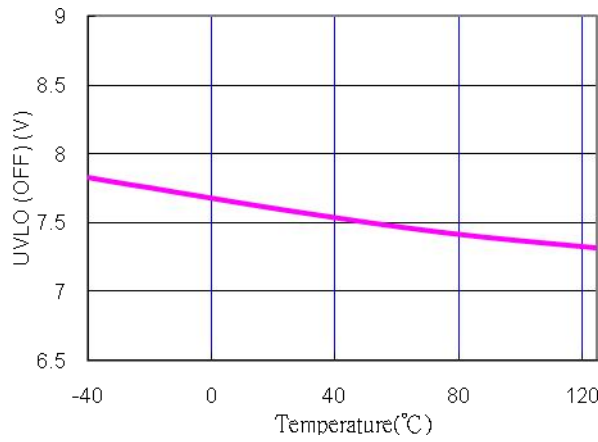


Fig. 3 UVLO (OFF) vs. Temperature

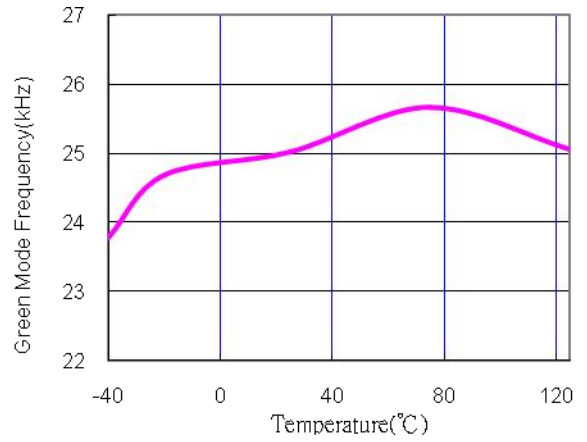


Fig. 4 Green Mode Frequency vs. Temperature

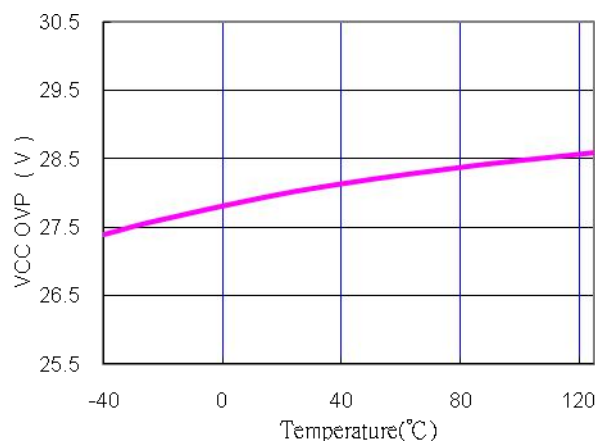


Fig. 5 VCC OVP vs. Temperature

## Application Information

### Overview

GR9235Q series is a high performance multi-mode (QR/DCM/Burst) PWM converter for flyback application. 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 2uA. Very low start-up current allows the PWM converter 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 GR9235Q 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 start-up. The hysteresis is show in Fig. 7.

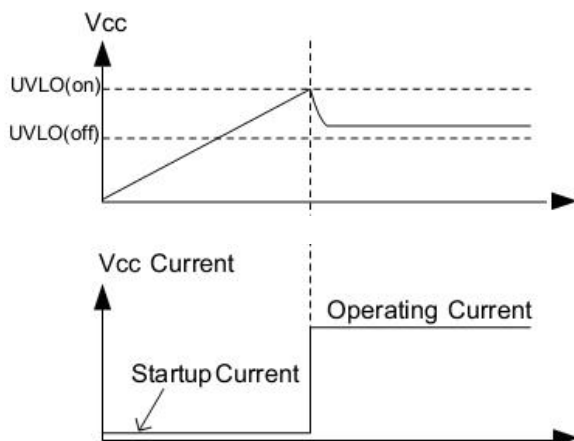


Fig.7

### Multi-Mode Operation

GR9235Q is a multi-mode (QR/DCM/Burst) converter. The operation of GR9235Q series 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 GR9235Q series will be shut down for reinforcement Green Energy-Saving.

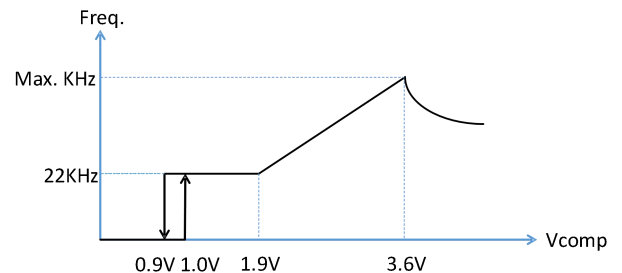


Fig.8

### Quasi-Resonant Detection

ZCD pin detects the leak of transformer and resonance of parasitic capacitance of MOSFET and turn on the MOSFET at nearby trough of wave of resonance to reduce the power loss and improve switching 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 the OCP 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 GR9235Q for being damaged from abnormal condition. When VCC voltage is higher than OVP level, the output of Gate driver will be shut down. VCC OVP is auto-recovery type. Once the condition of over voltage happened, the Gate driver will be shut down until the next VCC turn on. This



operation is a Hiccup mode. (Fig.9)

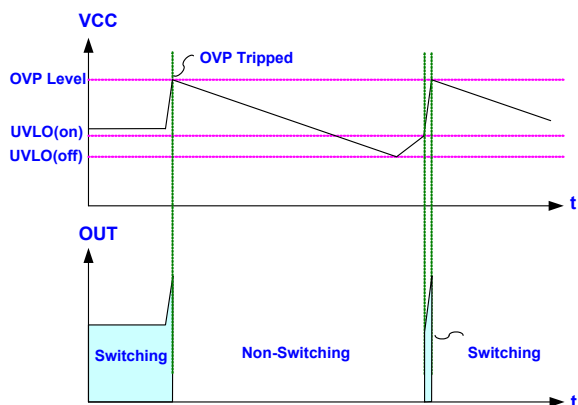


Fig.9

### Output OVP on ZCD - Auto Recovery mode

An output overvoltage protection is implemented in the GR9235Q, as shown in Fig. 10. It senses the auxiliary voltage via the divided resistors. The overvoltage protection works by sampling the plateau voltage after a delay time. The sampling voltage level is compared with internal threshold voltage 3.5V. If the sampling voltage exceeds the ZCD OVP trip level, ZCD OVP circuit switches the power MOSFET off. 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 QRD voltage declines below 0.8V for over 4cycle, the protection will be activated to turn off the gate until the next VCC UVLO-ON.

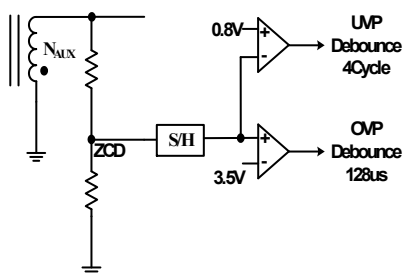


Fig.10

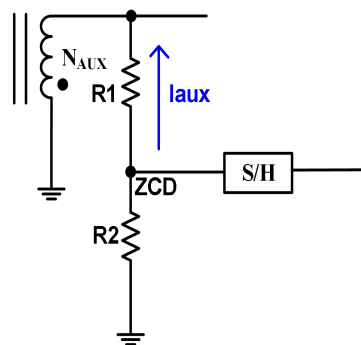


Fig.11

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

GR9235Q series have BNI/BNO function. This function is detected by internal circuit on ZCD pin, as show in Fig.11. If  $I_{aux} > I_{BNI}$ , the BNI Protection is triggered and the PWM starts to work. The de-bounce time is 2~5 CLK. During the BNI, If  $I_{aux} < I_{BNO}$ , the BNO protection is triggered and the PWM stops to work. The formula is as follows:

$$V_{ac\_BNI} = \frac{N_p}{N_{aux}} * I_{bni} * R1 * \frac{1}{\sqrt{2}}$$

$$V_{ac\_BNO} = \frac{N_p}{N_{aux}} * I_{bno} * R1 * \frac{1}{\sqrt{2}}$$

### Internal 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. The OCP compensation current flows through the internal resistors then makes the compensation voltage  $\Delta V_{cs}$  offset.

### Gate Clamp/Soft Driving

Driver output is clamped by an internal 12.5V 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.

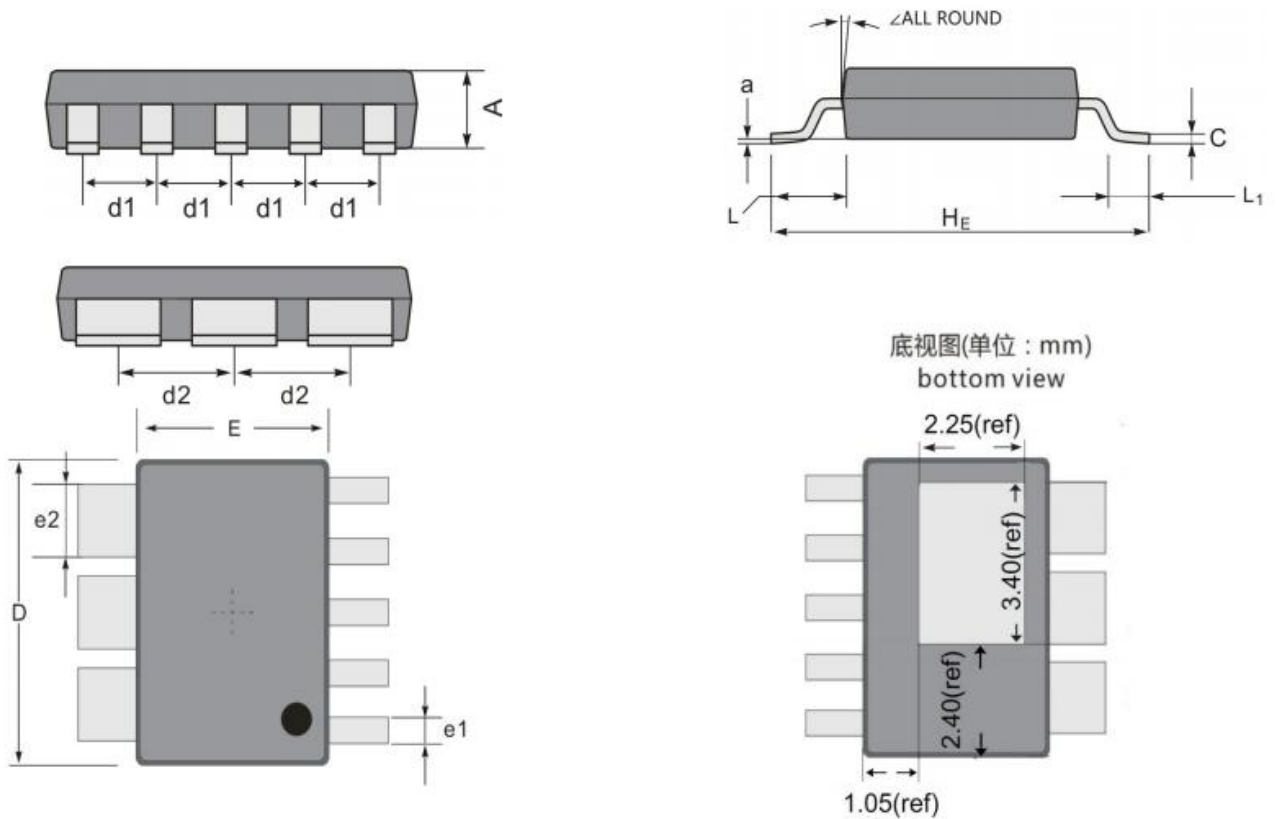
- OCP
- SCP
- OVP
- OLP
- Brown out

The GR9235Q 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, GR9235Q 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.

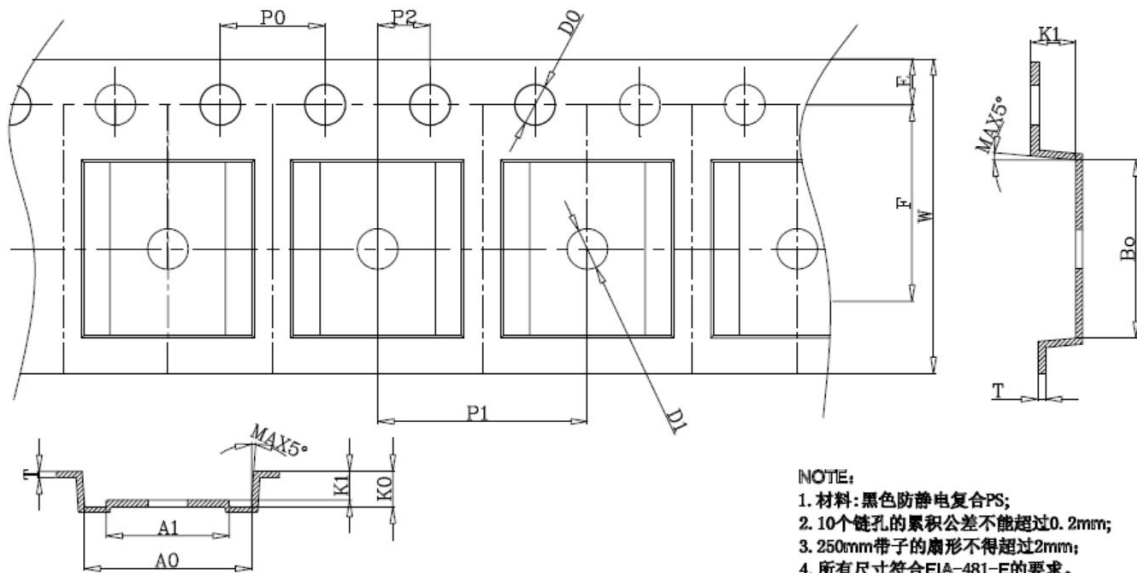
The VCC mode function is used to prevent the output re-start again when load changes. So never let the system operate on the VCC mode at no load. The system should operate on burst mode, otherwise the input power maybe become larger.

**封装信息**
**ESOP 6**


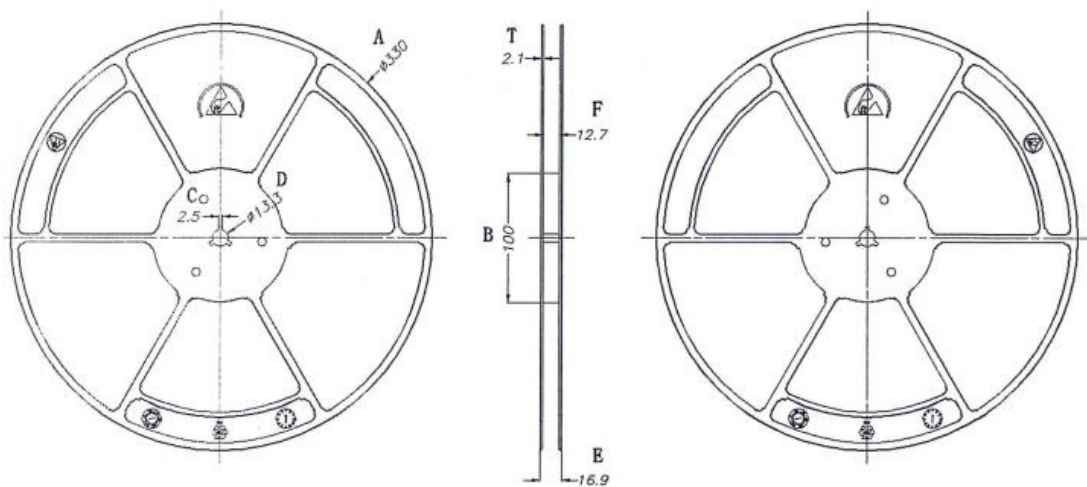
Unit		A	C	D	E	HE	d1	d2	e1	e2	L	L1	a	∠
mm	max	1.25	0.22	6.4	4.1	6.1	1.35	2.05	0.45	1.65	1.15	0.80	0.2 (ref)	12°
	typ	1.15	0.20	6.2	3.9	6.0	1.30	2.00	0.40	1.60	1.05	/		
	min	1.05	0.15	6.0	3.7	5.9	1.25	1.95	0.35	1.55	0.95	0.40		
mil	max	49	9	252	161	240	53	81	18	65	45	31	8 (ref)	
	typ	45	8	244	154	236	51	79	16	63	41	/		
	min	41	6	236	146	232	49	77	14	61	37	16		

## 包装信息

### (1) ESOP 6 打捲資訊



<b>SYMBOL</b>	<b>A0</b>	<b>B0</b>	<b>K0</b>	<b>P0</b>	<b>P1</b>	<b>P2</b>	<b>A1</b>	<b>K1</b>
<b>SPEC</b>	6.40±0.10	6.60±0.10	1.70±0.10	4.00±0.10	8.00±0.10	2.00±0.05	3.80±0.10	1.50±0.10
<b>SYMBOL</b>	<b>T</b>	<b>E</b>	<b>F</b>	<b>D0</b>	<b>D1</b>	<b>W</b>		
<b>SPEC</b>	0.25±0.05	1.75±0.10	5.50±0.05	1.55±0.05	1.55±0.05	12.0±0.30		



A±2	B±1	C±0.3	D±0.3	E±0.5	F <sup>+2</sup> <sub>-0.5</sub>	T±0.2
ø330	ø100	2.5	ø13.3	16.9	12.7	2.1

**(2) ESOP 6 包装数量**

封装形式	内包装		内盒		外箱		前空带/后空带
	包装	数量	袋数	数量	盒数	数量	
<b>ESOP 6</b>	13 寸蓝色卷盘	5K	2 个	10K	5 个	50K	20 格/80 格

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