MK2697A Wide-VCC Range, Multi-Mode HF QR Controller

1. Description

MK2697A is a highly integrated multiple-mode QR controller for high performance, low standby current and cost-effective offline flyback converter applications.

In order to achieve high efficiency from universal line with wide output voltage range across different load, MK2697A is self-adaptive to operate at DCM/QR modes accordingly with valley switching as much as possible.

MK2697A offers comprehensive protection features including output over-voltage protection (OVP), output over power protection (OPP), VCC over-voltage protection, BROWN-IN/OUT, and output short protection, Pin OPEN/SHORT protection.

MK2697A is available in SOT23-6 package.

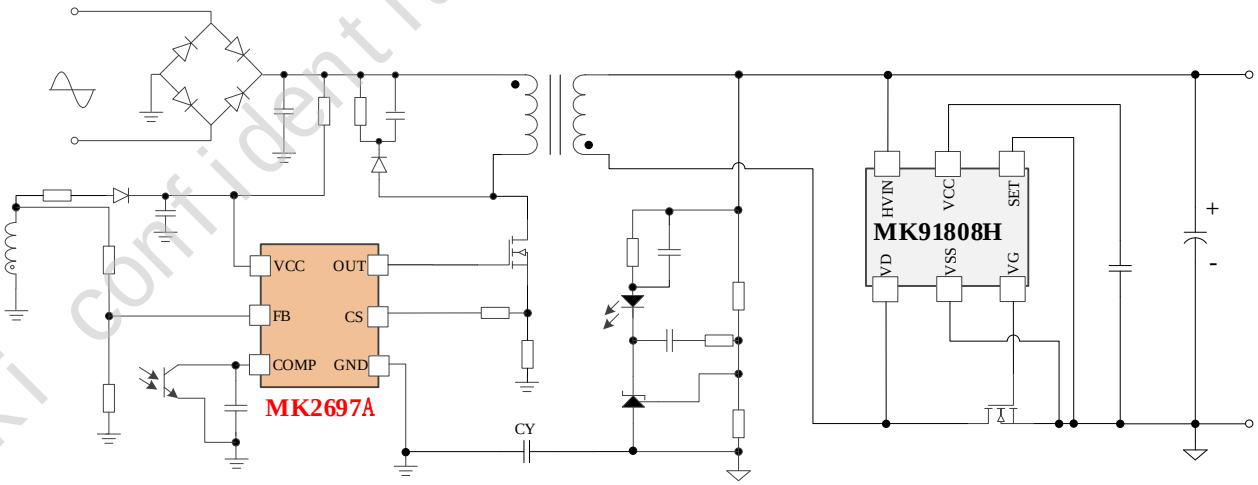
2. Typical Applications

- AC/DC Adapter
- AC/DC general power supply

3. Features

- Wide VCC Operating Range (10V to 88V)
- Working Frequency up to 130k Hz
- Adaptive Multi-Mode Control Optimized for Different Output Voltages and Load Currents
- Proprietary Soft-start Scheme to Achieve Low SR Vds Stress
- Optimized High Efficiency at Light Load
- OPP/SSCP Protection
- Brown-in /Brown-out Function
- VCC OVP /VO OVP Protection
- PIN OPEN/SHORT Protection
- External Programmable OTP Protection
- Support Wide Output Voltage Ranges
- Frequency Dithering to Improve EMI Performance
- Tiny SOT23-6 Package

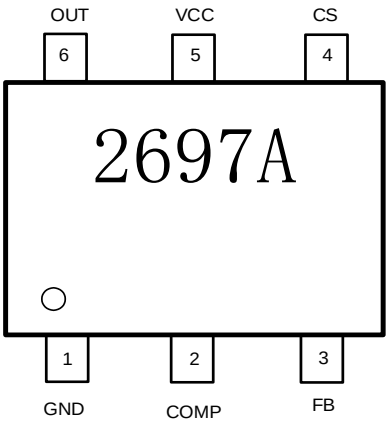
4. Simplified Application



5. Ordering Information

Ordering No.	Description
MK2697AGSA	SOT23-6, 3000 pcs/reel

6. Package Reference



SOT23-6

Absolute maximum Ratings (1)

VCC … ……. -0.3V to +100V
COMP, FB …… -0.3V to +5.5V
CS … ……. -0.7V to +5.5V
OUT ……-0.3V to +20V
Operating Junction Temperature.-40℃ to +150℃

Recommended Operation Conditions

VCC ……10V to 88V
Maximum Junction Temp. (T_J) ……+125°C

Thermal Resistance θ_{JA} θ_{JC}

SOT23-6……...… 110 74 °C/W

Notes:

(1) Exceeding these ratings may damage the device.

7. Electrical Characteristics

T_A=25°C, unless otherwise noted.

Parameter	Symbol	Conditions	Min	Typ	Max	Units
Supply Management Section						
VCC UVLO Rising	V_{CC_ON}		14.5	17	19.5	V
VCC UVLO Falling	V_{CC_OFF}		6	7.2	8.5	V
VCC UVLO Hysteresis	V_{CC_HYST}			10		V
VCC Startup current	$I_{STARTUP}$		2	5	10	uA
VCC Normal Operating Current	I_{OP}	COMP=2V, GATE=1nF to GND; Fsw=65kHz	1.4	2.5	3	mA
Burst Operating Current	I_{BURST}	COMP=0V, GATE=1nF to GND	200	280	400	uA
VCC Hold Threshold	V_{CC_HOLD}		7	8.3	9.6	V
VCC OVP Threshold	V_{CC_OVP}		89	93	100	V
VCC CLAMP Threshold	V_{CC_CLAMP}			102		V
Comp Input Section						
COMP Open Voltage	V_{COMP_OP}	COMP pin open-circuited		4.4		V
COMP Short-Circuit Current	I_{COMP_SHORT}	COMP=0V	100	150	250	uA
Burst Mode Entry Voltage	V_{BM_ET}		0.25	0.3	0.35	V
Burst Mode Hysterisis				0.05		V
OPP Protection Threshold	V_{OPP}		2.7	3	3.3	V
OPP Deglitch Time*	T_{D_OPP}			TSS*6		ms
COMP to CS Gain	A_{VCS}		2.4	2.5	2.6	V/V
Current Sense Input (CS PIN) Section						
Soft Start Time of CS Threshold	T_{SS}		4	7	10	ms
Leading Edge Blanking Time	T_{LEB}		200	330	500	ns
Secondary Rectifier short circuit trigger voltage (OC FAULT)	V_{SR_SH}		1.1	1.2	1.3	V
SR Short circuit deglitch cycles*				3		Cycles
Cycle by Cycle Current Limit	V_{CS_CBC}	VFB<1V,IFB=100uA	0.78	0.85	0.93	V

Cycle by Cycle Current Limit	V_{CS_CBC}	VFB<1V,IFB=300uA	0.5	0.65	0.7	V
Comp and Control Delay	T_{DL_CS}			130	200	ns
FB Input Section						
Brown-in Detection Threshold	I_{BNI}		82	94	106	uA
Brown-out Detection Threshold	I_{BNO}		74	85	96	uA
Brown-out Deglitch Time*	T_{BL_BNO}			Tss*7		ms
FB OVP Threshold	V_{FB_OVP}		3.3	3.6	3.9	V
FB OVP Deglitch Time*	T_{BL_OVP}			7		cycles
FB UVP Threshold (Output Short)	V_{FB_ST}		0.16	0.2	0.24	V
FB UVP Threshold (Output Short) Deglitch Time*	T_{BL_ST}			7		cycles
FB Sampling Time	T_{SAMPL}	CS=0.5V		1.4		us
Valley Detection Threshold	I_{FB_VALLEY}			10		uA
FB High Threshold	V_{FB_H}		1.7	1.9	2.1	V
FB Middle Threshold	V_{FB_M}		0.9	1	1.2	V
Gate Drive (OUT PIN) Section						
GATE Low Level	V_{G_L}			0.2	0.5	V
GATE High Level	V_{G_H}	VCC=13V,Gate Load=20mA	8	8.6		V
GATE Clamp Voltage	V_{G_HC}			11	12.5	V
GATE Rising Time	Tr	Cload=1nF	150	225	300	ns
GATE Falling Time	Tf	Cload=1nF	10	25		ns
Control Law						
Normal Mode Frequency	Fsw_max		117	130	143	kHz
Green Mode Frequency	Fsw_green			25		kHz
Dithering Range*				±6		%
Dithering Period*				8		ms
Maximum Toff Time	Toff_MAX		80	105	200	us
Thermal Shutdown Threshold*	Th_{SD}			155		℃
Thermal Shutdown Hysteresis*	Th_{SD_hys}			30		℃

Note

* Guaranteed by design

8. Pin Functions

Pin #	Name	Description
1	GND	Ground
2	COMP	Voltage feedback pin
3	FB	Auxiliary voltage sense
4	CS	Current Sense input
5	VCC	Power supply
6	OUT	Output to drive MOSFET

9. Block Diagram

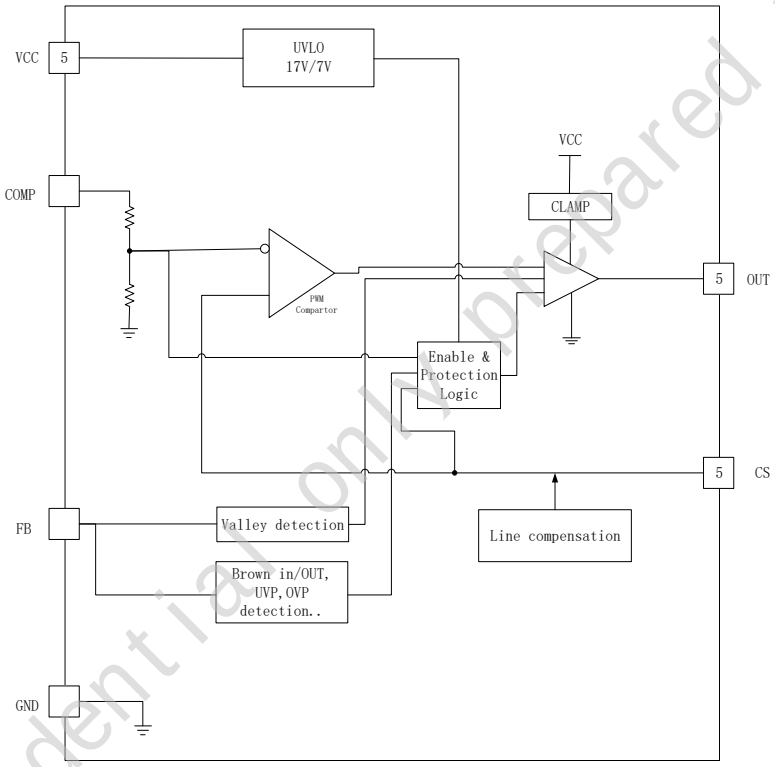


Figure 1. Functional Block Diagram

10. Operation Descriptions

Vcc and Start-up

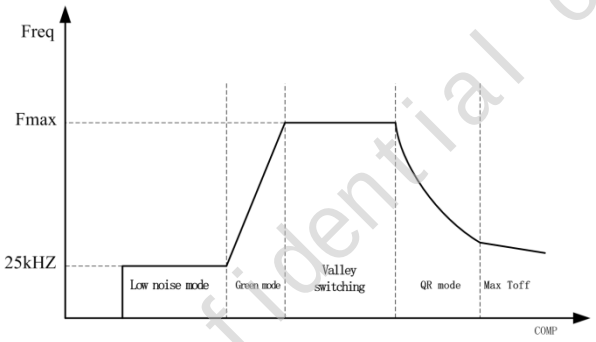
MK2697A's start-up current is only ~5 uA so that a large value of start-up resistor can be used to charge up VCC while minimize power loss during start-up. Once VCC reaches above UVLO threshold V_{CC_ON}, MK2697A starts switching.

Soft Start

MK2697A features an internal ~7ms soft-start to reduce electrical stress in power system during start-up. In order to reduce the voltage stresses from high peak current and high frequency switching further, MK2697A operates at optimized frequencies and control modes accordingly to output voltages and synchronous rectifier controller start-up status.

Operation Curve

MK2697A works on different modes which are based on COMP voltage and output voltage. In order to achieve optimal efficiency at certain output voltage range, MK2697 detects FB voltage to determine the switching frequency and working mode.



Brown in/ Brown out

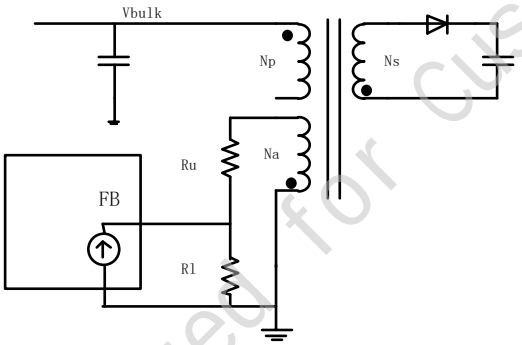
When the power MOSFET is turned on, the voltage at auxiliary windings is negative which makes Brown-in/Brown-out protection feasible.

When system starts up, power MOSFET is on, the current flow out of FB pin is equal to:

$$\frac{V_{BULK} * Na}{Ru * Np}$$

If this current is larger than I_{BNI} for four switching cycles, the controller starts to soft-start; otherwise, Brown-in auto-recovery protection is triggered.

During normal operation, when power MOSFET is turned on, the current at FB is less than I_{BN0} for at least T_{BL_BNO} (~49ms), the controller enters Brown-out auto-recovery protection.



Current Sense(OPP)

MK2697A is current mode PWM controller. Cycle-by-cycle current limiting is offered. The switch current is detected by a sense resistor at CS pin. An internal leading-edge blanking circuit with T_{LEB} blanking time blocks the sensed voltage spikes at initial power MOSFET on state due to snubber diode reverse recovery and surge gate current at power MOSFET. The maximum cycle-by-cycle current limit is set by V_{CS_CBC}/R_{CS}.

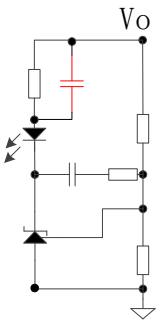
Line Compensation

MK2697A uses the detected input line voltage through the current at FB pin (I_{FB}) to generate the offset voltage added on internal current signal to compensate the output OPP power level. This mechanism helps achieve flat OPP power level over different input voltage.

Voltage Feedback Loop

COMP is the voltage loop feedback pin which is connected to TL431 output through opto-coupler. In order to support wide COMP range, a ratio of 1/2.5 resistor divider is used before it goes to PWM comparator.

A ceramic capacitor is suggested to put parallel with the resistor which is series with optocoupler diode.



FB Voltage Detection

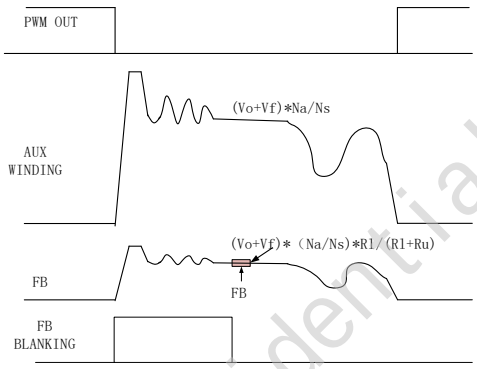
MK2697A detects the transformer core demagnetization by monitoring the signal at the auxiliary windings through FB pin.

By detecting FB voltage during demagnetization time, MK2697 is able to do the following functions:

Output over voltage protection (OVP): FB is above V_{FB_OVP} (~3.6V) for 7 switching cycles

Output under voltage protection (output short circuit protection): FB is below V_{FB_ST} (~0.2V) for 7 switching cycles

Determine control mode and switching frequency based on V_{FB_H}, V_{FB_M}。



MK2697A implements a FB blanking time to block the switching noise at the beginning of the transformer demagnetizing time. The FB blanking time is proportional to Vcs since the switching noise is generally bigger with larger peak current.

Valley Switching

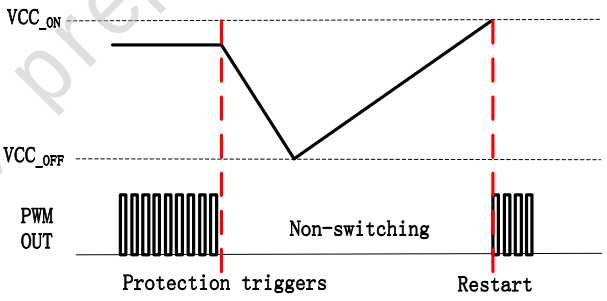
After secondary side rectification is done, the drain voltage starts oscillating with a frequency of approximately

$$1/2\,\pi\sqrt{Coss * L_P},$$

where Lp is the inductance of primary winding of the transformer and COSS is capacitance on the drain of primary MOSFET. When the oscillation ringing is below 0 at auxiliary winding, MK2697A clamps FB pin to ~0V, and senses the current at FB pin. When the current out of FB reaches a design value, a “possible” valley is locked and MK2697A turns on after propagation delay. If DCM ringing is dampened very quickly so that a valley is not able to be determined, MK2697 is going to turn on after 3us from falling edge of internal oscillator clock.

Protection

Reliable power supply system is achieved with auto-recovery protections including cycle-by-cycle current limit, over-power-protection (OPP), output over-voltage protection, etc. Detailed protection features are described in the following sessions.



MK2697A PROTECTION FEATURES	MK2697A PROTECTION SCHEMES
OPP	RESTART
VO_OVP	RESTART
VCC_OVP	RESTART
CS_SHORT	RESTART
SSCP	RESTART
FB_UVP (VO_SCP)	RESTART

Over Power Protection

OPP is achieved by monitoring COMP voltage. If COMP voltage is above V_{OPP} for at least 7 times of soft-start time, MK2697A enters auto-recovery OPP protection.

Secondary Short Circuit Protection (SSCP)

If secondary side synchronous rectifier is short circuit, peak current increases rapidly after power MOSFET is turned on, thus the protection needs to react in much less wait time. MK2697A shortens current sense blanking time to T_{LEB_SRSH} if CS pin detects a voltage above V_{SR_SH} (~1.2V) threshold, and turns off power MOSFET immediately for current switching cycle. If this happens for consecutive three switching cycles, controller goes to auto-recovery SSCP protection.

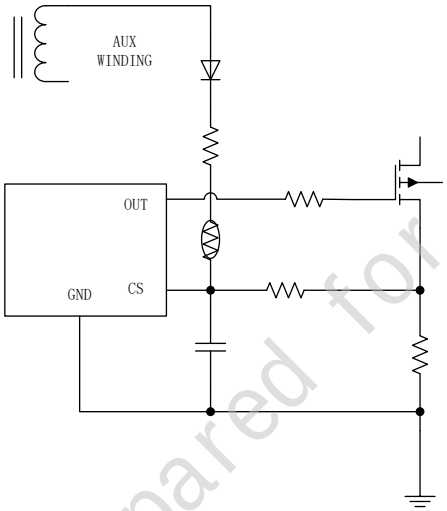
Vcc Ovp

Whenever the VCC voltage is higher than the OVP threshold voltage VCC_OVP , the output gate drive circuit will be shutdown simultaneously to stop the switching of the power MOSFET and goes to auto-recovery protection.

OTP

There is OTP protection inside MK2697A with Thsd triggering temperature.

MK2697A is implemented over temperature protection outside on CS pin which senses voltage to monitor NTC status during MOSFET off region. If VCS is greater than V_{CS_CBC} and continues for 15 cycles, OTP is triggered, MK2697A goes to auto-recovery OTP protection.

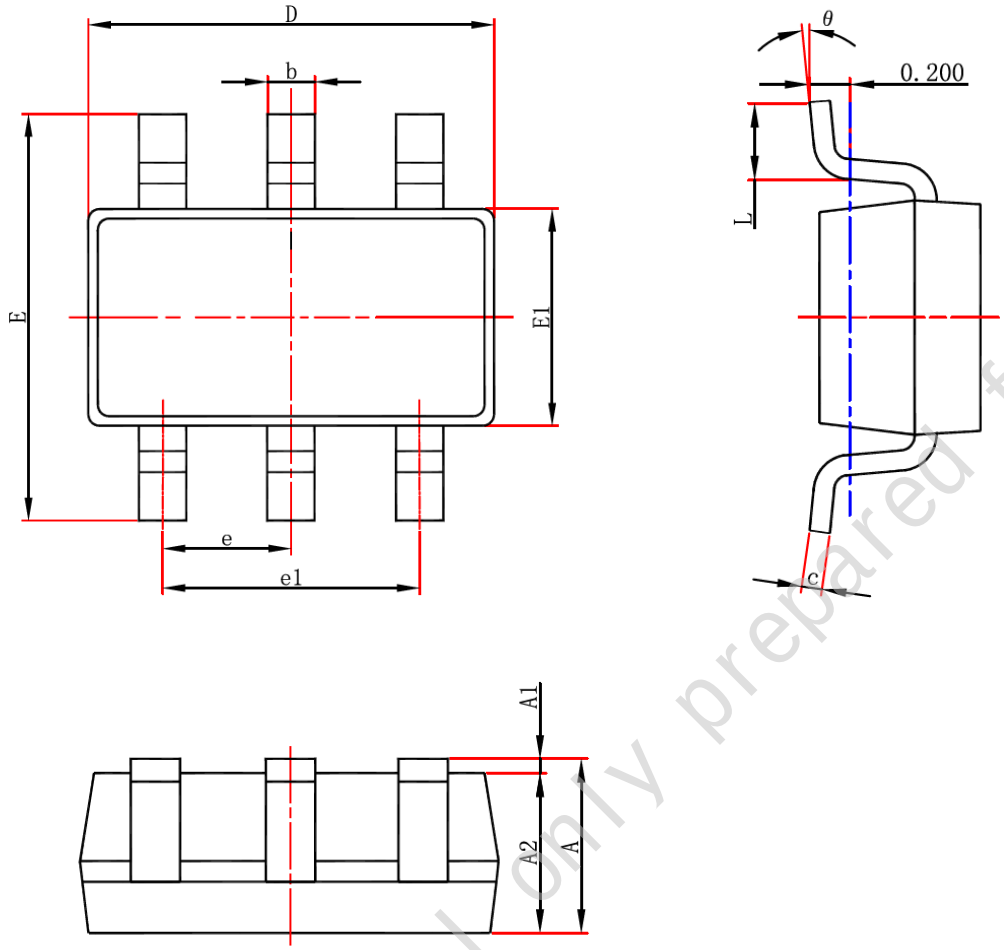


Pin Open Short Protection

There are several critical protections designed in the MK2697A to prevent the power supply at fault state. In case listed below, MK2697A will trigger protection:

- Adjacent PINS short
- PINS open
- CS short

11. Package Information (SOT23-6)



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E1	1.500	1.700	0.059	0.067
E	2.650	2.950	0.104	0.116
e	0.950(BSC)		0.037(BSC)	
e1	1.800	2.000	0.071	0.079
L	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°