LD7932M

04/10/2013

Green Mode Off-line Power Switch with Brown-Out Protections

REV. 00

General Description

The LD7932M is integrated with a 600V power MOSFET and a current mode PWM controller in a DIP-7 package. It takes less components counts or circuit space, especially ideal for those total solutions of low cost.

The implemented functions include low startup current, green-mode power-saving operation, leading-edge blanking of the current sensing and internal slope compensation. It also features more protections like OLP (Over Load Protection) and OVP (Over Voltage Protection) to prevent circuit from being damaged under abnormal conditions.

Furthermore, the Frequency Swapping function is to reduce the noise level and thus helps the power circuit designers to easily deal with the EMI filter design by spending minimum amount of component cost and developing time.

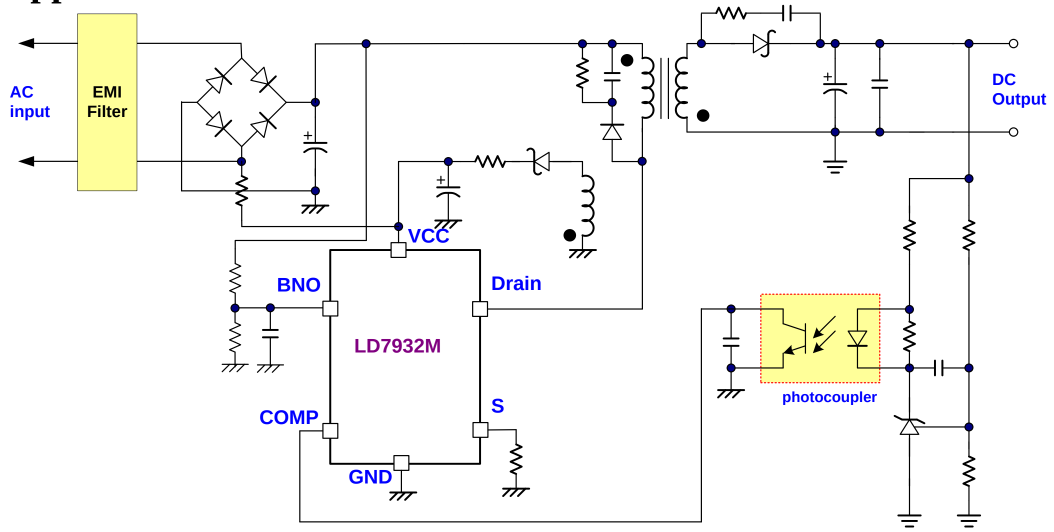
Features

- Built-in 600V Power MOSFET
- High-Voltage CMOS Process with Excellent ESD Protection
- Very Low Startup Current (<17μA)
- Current Mode Control
- Green Mode Control
- UVLO (Under Voltage Lockout)
- LEB (Leading-Edge Blanking) on CS Pin
- Internal Frequency Swapping
- Internal Slope Compensation
- OVP (Over Voltage Protection) on Vcc Pin
- Brownout Protection
- OLP (Over Load Protection)

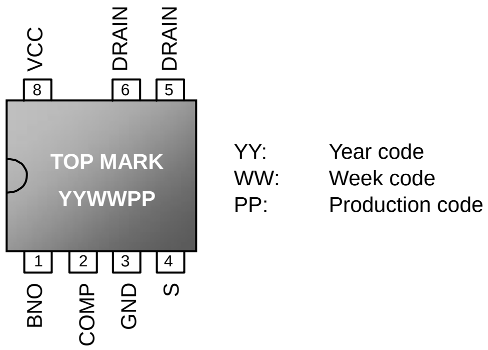
Applications

- Switching AC/DC Adaptor
- Open Frame Switching Power Supply

Typical Application



Pin Configuration



Ordering Information

Part number	Package	Top Mark	Shipping
LD7932M GM7	DIP-7	LD7932MGM7	3600 /tube /Carton

The LD7932M is Green Packaged/ ROHS compliant.

Protection Mode

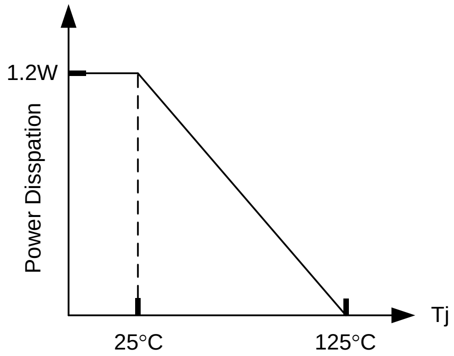
Switching Freq.	VCC OVP	OLP	BNO Pin
65kHz	Auto recovery	Auto recovery/ 65ms	Auto recovery

Pin Descriptions

PIN	NAME	FUNCTION
1	BNO	Brownout Protection Pin. Connect a resistor divider with this pin to AC mains input to set the brownout level and line compensation. If its voltage drops below threshold voltage, the PWM output will be turned off.
2	COMP	Voltage feedback pin (same as the COMP pin in UC384X). Connect a photo-coupler to close the control loop and achieve the regulation.
3	GND	Ground of the controller
4	S	Source of internal power MOSFET. Connect a sense resistor to ground.
5	Drain	Drain terminal of the internal power MOSFET
6	Drain	Drain terminal of the internal power MOSFET
8	VCC	Supply voltage pin

Output Power Table & De-rating Curve

Product	Drain Current	Rds(on) *	230VAC ± 15% **		90~264VAC **	
			Adapter	Open Frame	Adapter	Open Frame
LD7932M	2A	4.7Ω	14W	16W	12W	14W



*Typ.@25°C, V_{CC}=10V Drain Current=1A

**Calculated maximum Input Power Rating at Ta=25°C

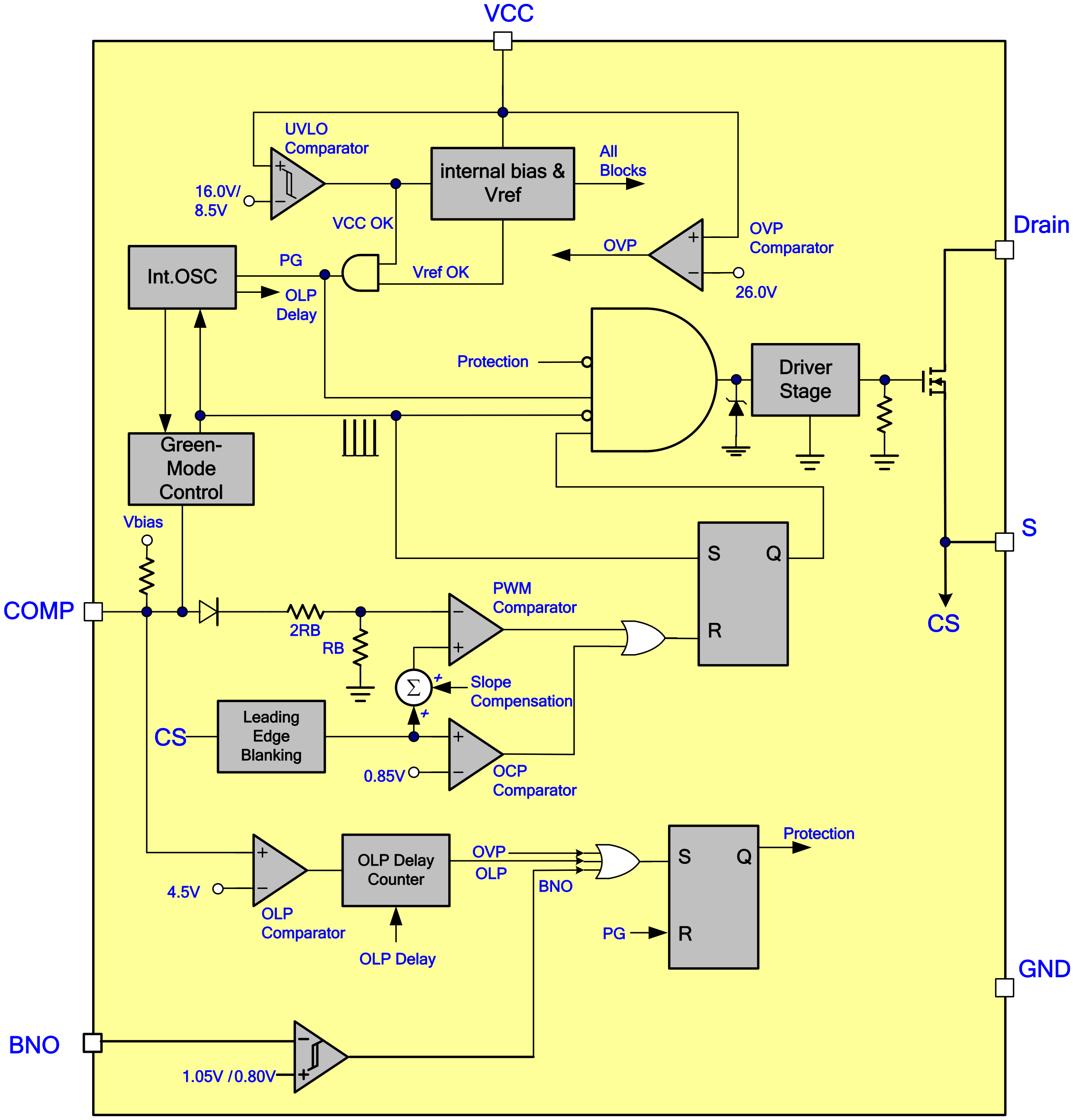
Recommended Operating Conditions

Item	Min.	Max.	Unit
Supply Voltage Vcc	10	24	V
Start-up resistor Value	540K	1.8M	Ω
COMP pin Capacitor Value	4.7	220	nF

Note:

1. It's essential to connect a capacitor with COMP pin to filter out the undesired switching noise for stable operation.
2. Place the small signal components close to IC pin as possible.

Block Diagram



Absolute Maximum Ratings

Supply Voltage VCC	-0.3V ~29V
COMP, BNO, S	-0.3V ~6V
OUT	-0.3V ~Vcc+0.3V
Drain	-0.3V ~600V
Drain current (Note), TC=25°C	2.0A
Maximum Junction Temperature	150°C
Operating Ambient Temperature	-20°C to 85°C
Operating Junction Temperature	-40°C to 125°C
Storage Temperature Range	-65°C to 150°C
Package Thermal Resistance (DIP-7, θ_{JA})	80°C/W
Total Power Dissipation of DIP-7, Ta=25°C	1.2W
Lead Temperature (Soldering, 10sec)	260°C
ESD Voltage Protection, Human Body Model (Drain pin excluded)	2.5 KV
ESD Voltage Protection, Human Body Model (Drain pin)	1 KV
ESD Voltage Protection, Machine Model	250 V

Note:

1. Repetitive rating: pulse width limited by maximum junction temperature
2. In condition of no heat-sink on natural convection

Caution:

Stress exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stress above Recommended Operating Conditions may affect device reliability.

Electrical Characteristics

(T_A = +25°C unless otherwise stated, V_{CC}=15.0V)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Supply Voltage (Vcc Pin)					
Startup Current		---	12	17	μA
Operating Current (with 1nF load on OUT pin)	V_{COMP}=0V	0.65	0.9	1.25	mA
	V_{COMP}=3V	1.4	2.0	2.5	mA
	OLP Tripped/ Auto	0.3	0.4	0.55	mA
	OVP Tripped/ Auto	0.3	0.4	0.55	mA
$UVLO_{(OFF)}$		7.5	8.5	9.5	V
$UVLO_{(ON)}$		15	16	17	V
OVP Level		25	26	27	V
Voltage Feedback (COMP Pin)					
Short Circuit Current	V_{COMP}=0V	0.2	0.25	0.32	mA
Open Loop Voltage	COMP pin open	4.8	5.4	6.0	V
Green Mode Threshold VCOMP	*	---	2.4	---	V
Zero Duty Threshold VCOMP		1.37	1.5	1.63	V
Zero Duty Hysteresis		70	100	130	mV
Current Sensing (CS Pin)					
Max. Input Voltage, V_{CS_OFF}		0.8	0.85	0.9	V
Max. Input Voltage, V_{CS_MIN}	For high line	0.6	0.65	0.7	V
Leading Edge Blanking Time		---	350	---	ns
Internal Slope Compensation	0% to D_{MAX}. (linearly increase)*	---	300	---	mV
Input impedance	*	1	---	---	MΩ
Delay to Output	*	---	100	---	ns
Max. Duty	*	70	75	80	%
Oscillator for Switching Frequency					
Frequency, FREQ		60	65	70	kHz
Green Mode Frequency, FREQG		---	25	---	kHz
Frequency Swapping		---	± 4.0	---	kHz
Temp. Stability	(-20°C ~85°C) *	---	5	---	%
Voltage Stability	(VCC=11V-25V) *	---	---	1	%

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
OLP (Over Load Protection)					
OLP Trip Level		4.3	4.5	4.7	V
OLP Delay Time		---	65	---	ms
Brownout Protection (BNO Pin)					
Brownout Turn-On Trip Level		1.00	1.05	1.10	V
Brownout Turn-Off Trip Level		0.75	0.80	0.85	V
BNO Pin De-bounce Time		---	250	---	μs
On Chip OTP (Over Temperature)					
OTP Level	*	---	140	---	°C
OTP Hysteresis	*	---	30	---	°C
Soft Start Duration					
Soft Start Duration	*	---	5	---	ms

*: These parameters are guaranteed by design.

Electrical Characteristics for MOSFET

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Drain to Source Breakdown Voltage					
Breakdown Voltage BV_{DSS}	V_{CC}=0V, COMP=0V, I_D=250μA	600	---	---	V
Drain Leakage Current					
Drain-Source Leakage Current	V_{DS}=600V, V_{CC}=0V, T_J=25°C	0	---	1	μA
Drain on Resistance					
Drain to S pin On-Resistance	I_D=1A; V_{CC}=10V; Tj=25°C	---	4.7	---	Ω

Typical Performance Characteristics

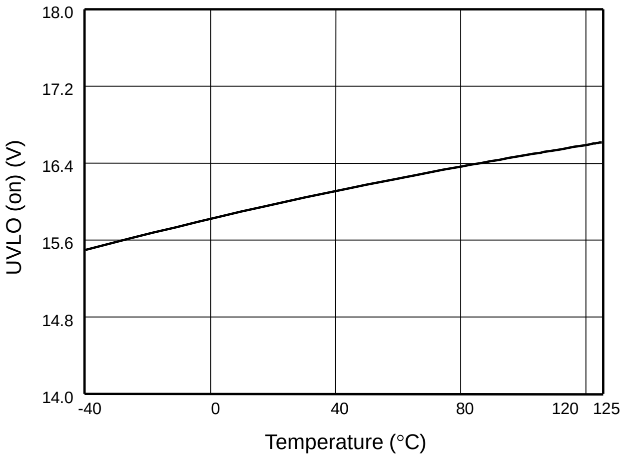


Fig. 1 UVLO (on) vs. Temperature

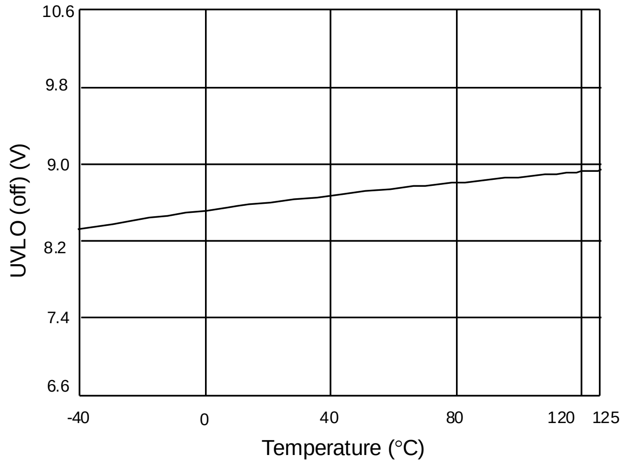


Fig. 2 UVLO (off) vs. Temperature

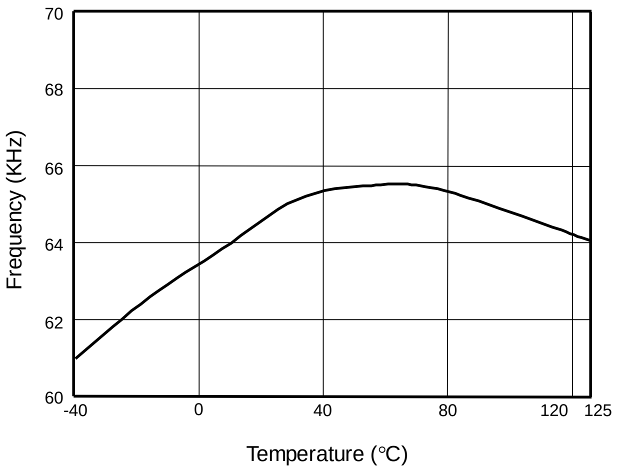


Fig. 3 Frequency vs. Temperature

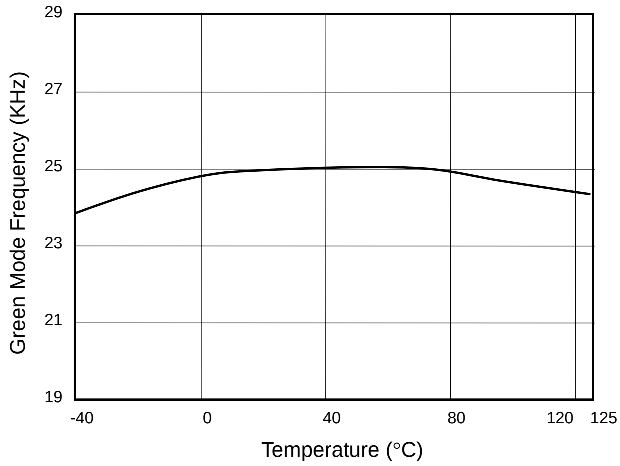


Fig. 4 Green Mode Frequency vs. Temperature

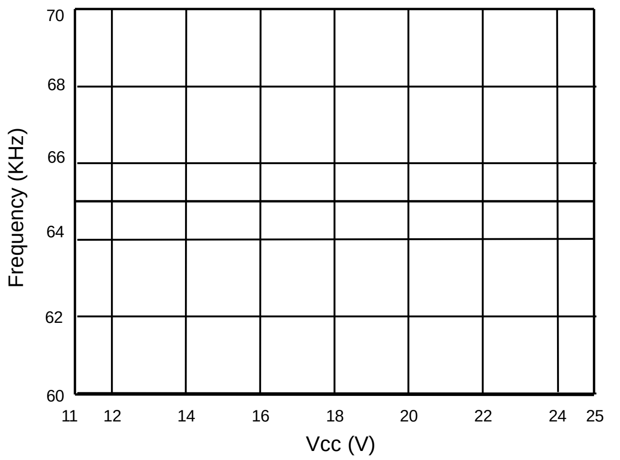


Fig. 5 Frequency vs. Vcc

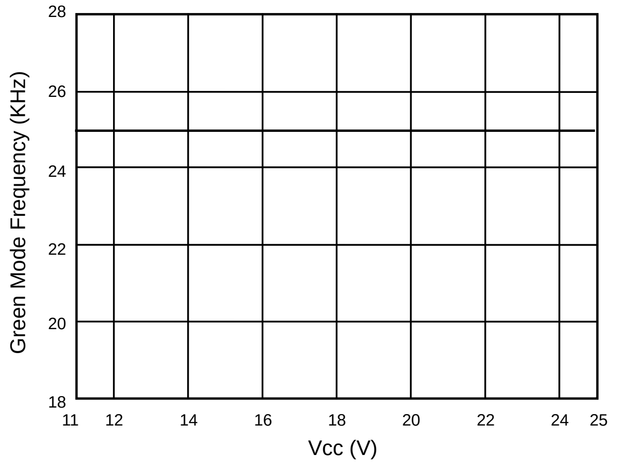


Fig. 6 Green Mode Frequency vs. Vcc

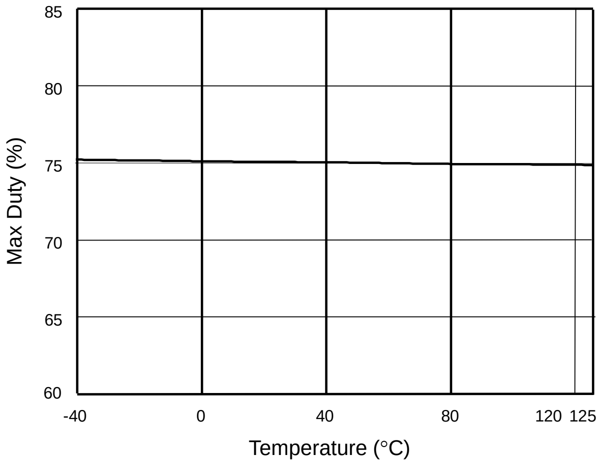


Fig. 7 Max Duty vs. Temperature

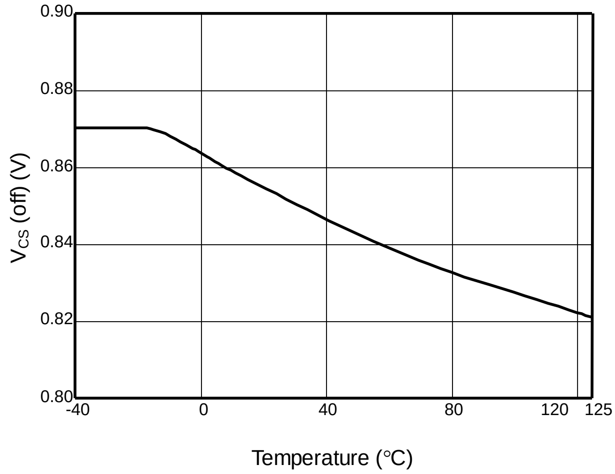


Fig. 8 V_{CS} (off) vs. Temperature

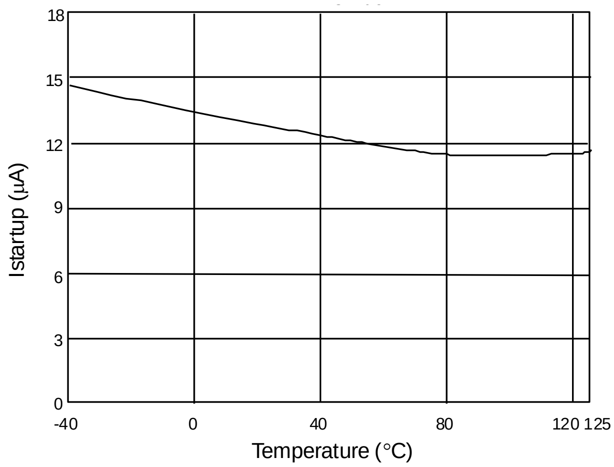


Fig. 9 Startup Current (Istartup) vs. Temperature

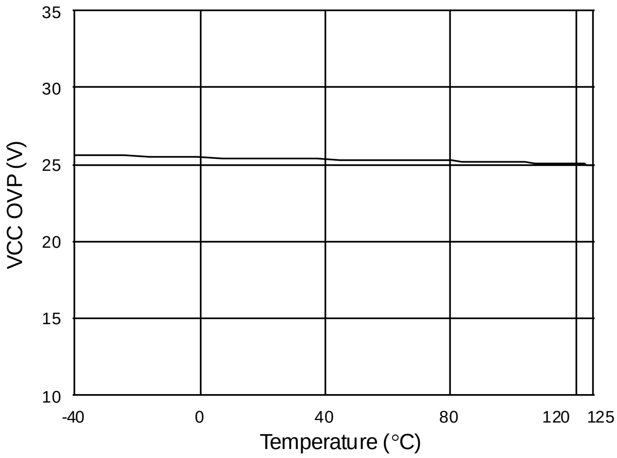


Fig. 10 VCC OVP vs. Temperature

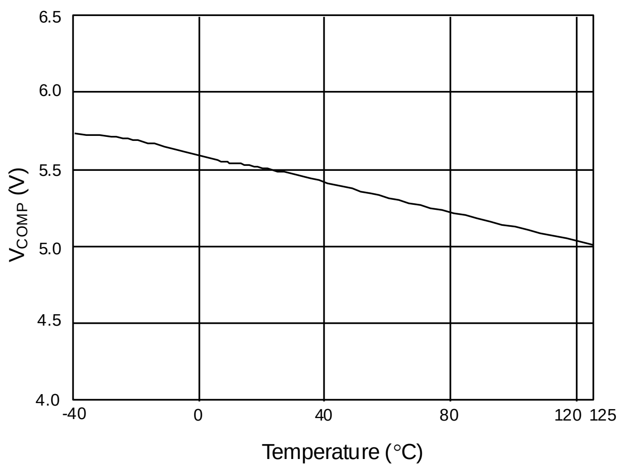


Fig. 11 V_{COMP} open loop voltage vs. Temperature

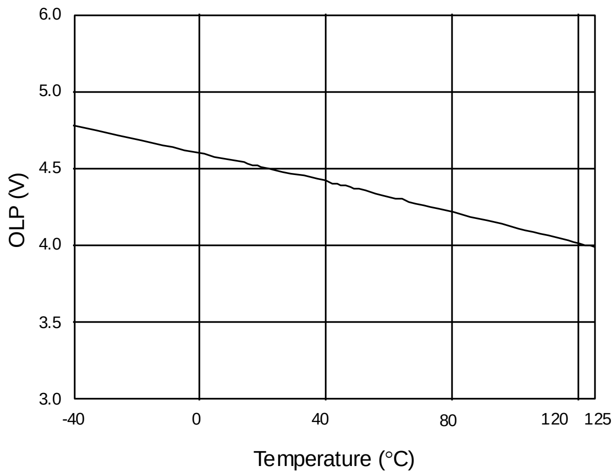


Fig. 12 OLP-Trip Level vs. Temperature

Application Information

Operation Overview

The LD7932M meets the green-power requirement and is intended for the use in those modern switching power suppliers and adaptors which demand higher power efficiency and power-saving. It integrates more functions to minimize the external components counts and the size. Its major features are described as below.

Under Voltage Lockout (UVLO)

An UVLO comparator is implemented in it to detect the voltage across VCC pin. It would assure the supply voltage enough to turn on the LD7932M PWM controller and further to drive the power MOSFET. As shown in Fig. 13, a hysteresis is built in to prevent shutdown from the voltage dip during startup. The turn-on and turn-off threshold level are set at 16.0V and 8.5V, respectively.

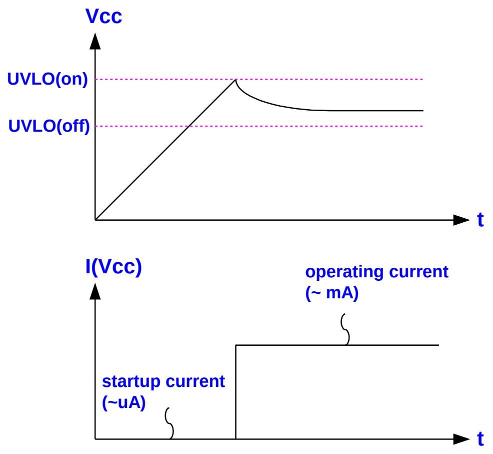


Fig. 13

Startup Current and Startup Circuit

The typical startup circuit to generate V_{CC} of the LD7932M is shown in Fig. 14. During the startup transient, the V_{CC} is below UVLO threshold. Before it has sufficient voltage to develop OUT pulse to drive the power MOSFET, R1 will provide the startup current to charge the capacitor C1. Once V_{CC} obtains enough voltage to turn on the LD7932M and further to deliver the gate drive signal, it will enable the auxiliary winding of the transformer to provide supply current. Lower startup current requirement for the PWM controller will help to optimize the value of R1 and then minimize the power consumption for R1. By using CMOS process and the special circuit design, it requires only 17μA for the maximum startup current.

A larger resistor of R1 will usually spend much more time to start up. By carefully selecting values for R1 and C1 will optimize the power consumption and startup time.

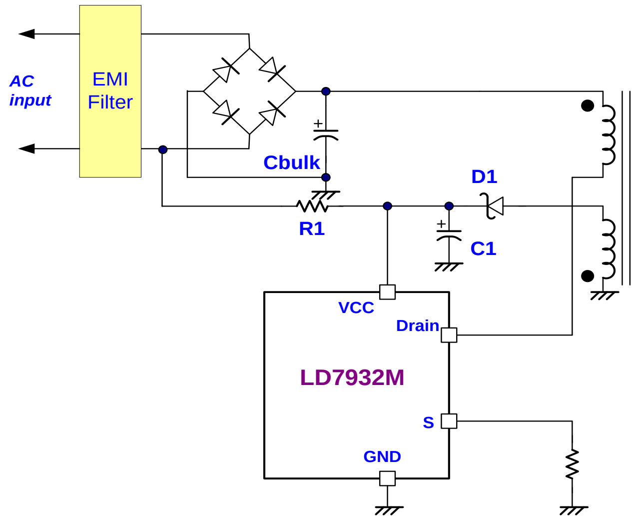


Fig. 14

Current Sensing and Leading-edge Blanking

The typical current mode of PWM controller feedbacks both current signal and voltage signal to close the control loop and achieve regulation. The LD7932M detects the primary MOSFET current across CS pin for the peak current mode control and also for the pulse-by-pulse current limit.

In general, the power converter will provide more current when input voltage alters to high due to the signal propagation delay. This can be compensated through LD7932M. It's controlled by adjusting the current limit with the duty cycles in corresponding to Vcs_off. As shown in Fig.15, Vcs_off (corresponding to current limit) is in direct proportion to duty ratio in a certain segment and is fixed at high or low if duty ratio is over or below threshold values, respectively. As a result, the current limit will be lowered at high-line inputs. This compensation control mechanism is developed with patents pending by Leadtrend Technology.

The maximum voltage threshold of the current sensing pin is set at 0.85V for low-line input. Thus the MOSFET peak current can be calculated as:

$$I_{PEAK(MAX)} = \frac{0.85V}{R_S}$$

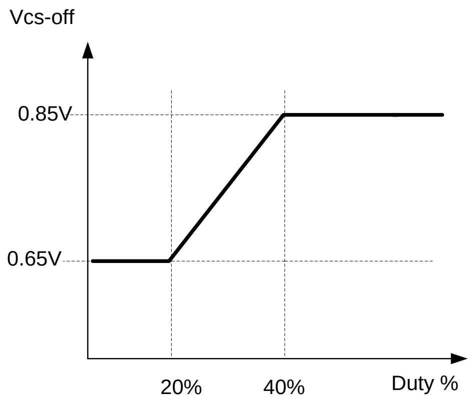


Fig. 15

A leading-edge blanking (LEB) time is included in the input of CS pin to prevent the false-trigger from the current spike. (As shown in Fig.16).

Maximum Duty-Cycle

The maximum duty-cycle of LD7932M is limited to 75% to avoid the transformer saturation.

Voltage Feedback Loop

The voltage feedback signal is provided from TL431 at the secondary side through the photo-coupler to the COMP pin of the LD7932M. Similar to UC3842, the LD7932M would carry a diode voltage offset at the stage to feed the voltage divider at the ratio of RA and RB, that is,

$$V_{-(PWM_{COMPARATOR})} = \frac{RB}{RA+RB} \times (V_{COMP} - V_F)$$

A pull-high resistor is embedded internally and no external resistor is required.

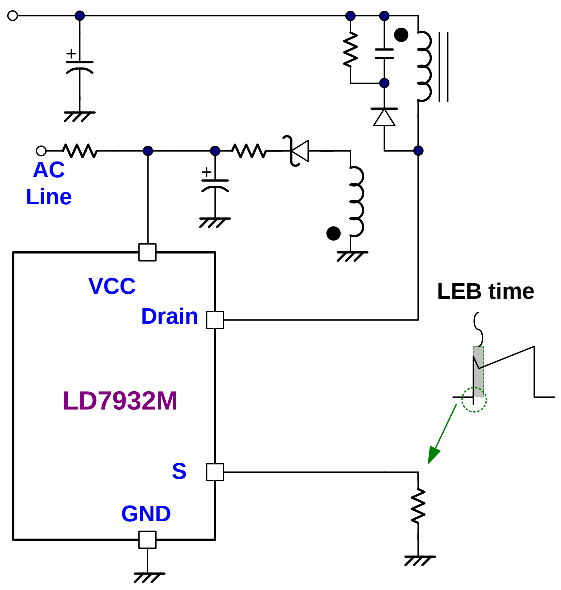


Fig. 16

Internal Slope Compensation

In the conventional applications, the problem of the stability is a critical issue for current mode controlling, when it operates over 50% duty-cycle. It injects a current ramp to increase slope compensation to RT/CT pin through a coupling capacitor. It therefore requires no extra design for the LD7932M since it has this function built-in already.

On/Off Control

The LD7932M can be turned off by pulling COMP pin below 1.5V. The gate output pin of the LD7932M will be disabled immediately under such condition. The off-mode can be released when the pull-low signal is removed.

Over Load Protection (OLP) – Auto Recovery

To protect the circuit from damage due to over-load condition, short or open-loop condition, the LD7932M is implemented with smart OLP function for it. It also features auto recovery function; see Fig. 17 for the waveform. In case of fault condition, the feedback system will force the voltage loop toward to the saturation and then pull the voltage high over COMP pin (VCOMP). When the V_{COMP} ramps up to the OLP threshold of 4.5V and continues for over OLP delay time, the protection will be activated and then turn off the gate output to stop the switching of power circuit.

With the protection mechanism, the average input power will be minimized to remain the component temperature and stress within the safety operating area.

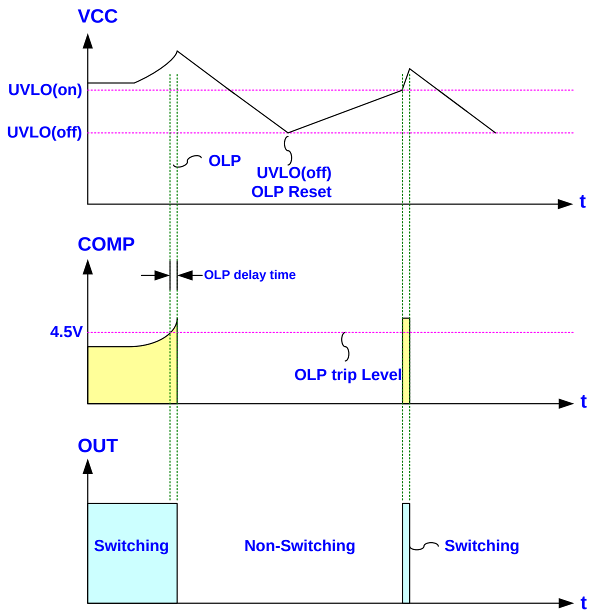


Fig. 17

OVP (Over Voltage Protection) on Vcc – Auto Recovery

The maximum VGS ratings of the power MOSFETs are mostly for 30V. To prevent the VGS from entering fault condition, LD7932M is implemented with OVP function over Vcc. As the Vcc voltage rises over OVP threshold, the output gate drive circuit will be shut off simultaneously and the switching of the power MOSFET is disabled until the next UVLO(on).

The Vcc OVP function is auto-recoverable. If the OVP condition is not released, which is usually caused by open-loop of feedback, the Vcc will trip to OVP level and shut down the output again. The Vcc works in hiccup mode. Fig. 18 shows its operation. Otherwise, once the OVP condition is removed, the Vcc level will resume and the output will automatically return to the normal operation.

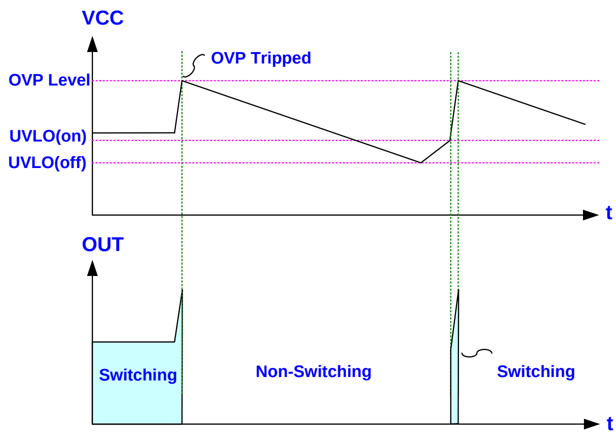


Fig. 18

Brownout Protection

The LD7932M is programmable to set the brownout protection point though BNO pin. The voltage across the BNO pin is proportional to the bulk capacitor voltage, referred as the line voltage. A brownout comparator is implemented to detect the abnormal line condition. As soon as the condition is detected, it will shut down the controller to prevent the damage. Fig. 19 shows the operation. When VBNO falls below 0.80V, the gate output will be kept off even Vcc has already achieved UVLO(ON). It therefore makes Vcc hiccup between UVLO(ON) and UVLO(OFF). Unless the line voltage is large enough to pull VBNO larger than 1.05V, the gate output will not start switching even when the next UVLO(ON) is tripped. A hysteresis is implemented to prevent the false trigger during turn-on and turn-off. Fig. 20 shows the circuit.

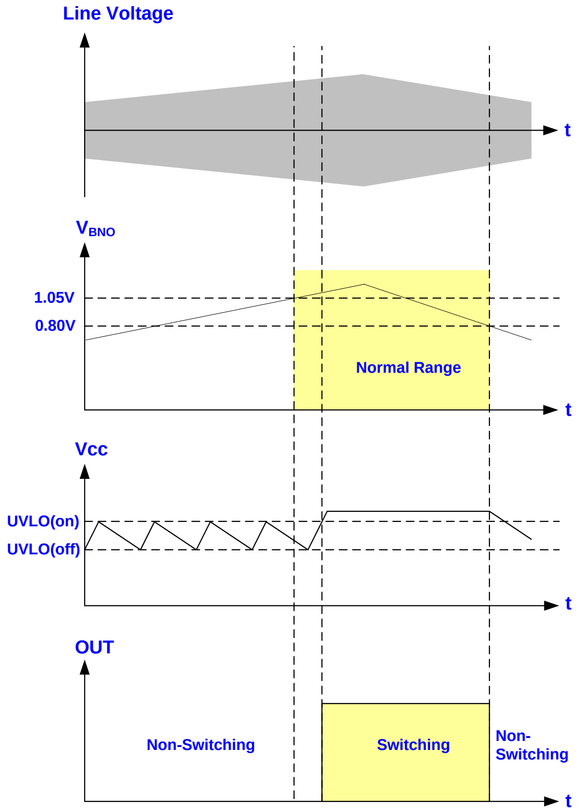


Fig. 19

Oscillator and Switching Frequency

The LD7932M is implemented with Frequency Swapping function which helps the power supply designers to both optimize EMI performance and reduce system cost. The switching frequency substantially centers at 65KHz, and swap between a range of ±4KHz.

Green-Mode Operation

By using the green-mode control, the switching frequency can be reduced to improve the efficiency at light load. The green-mode control is Leadtrend Technology's own property.

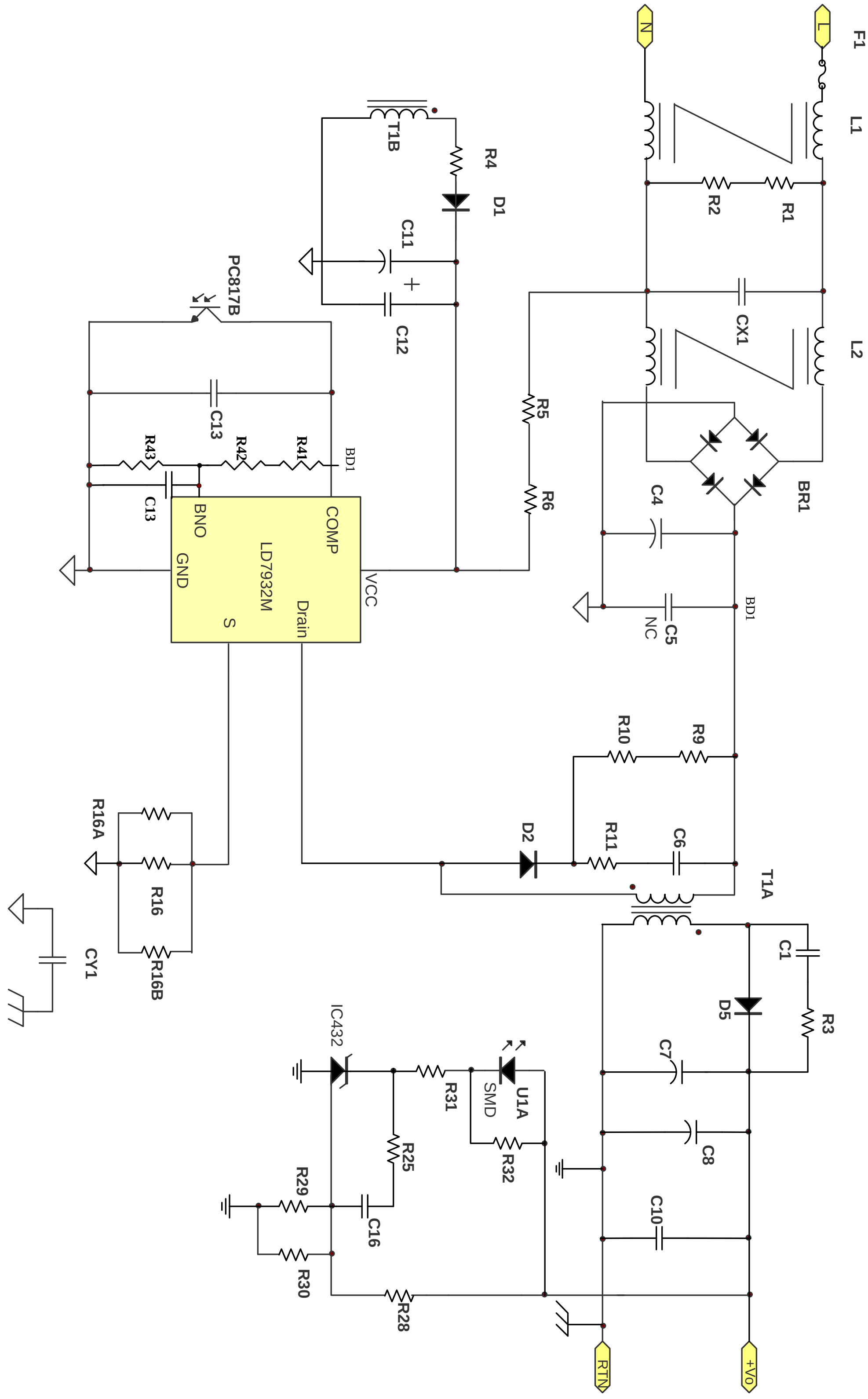
Fault Protection

There are several critical protections integrated in the LD7932M to prevent the power supply from damage. Those damages usually happen in open or short conditions on the pins of LD7932M.

In case under such conditions listed below, the gate output will turn off immediately to protect the power circuit.

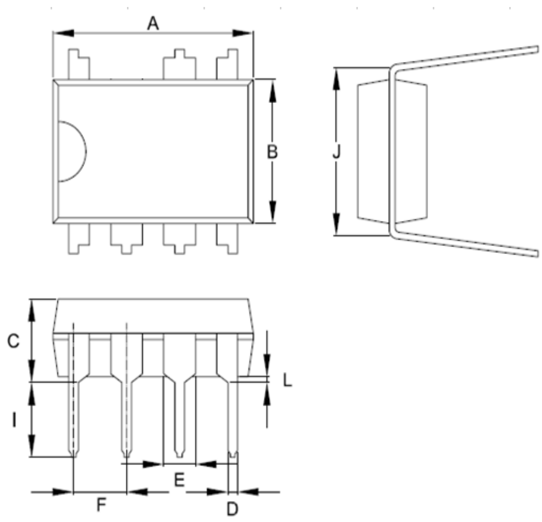
1. CS pin floating
2. COMP pin floating

Reference Application Circuit --- 12.5W (5V/2.5A)



Package Information

DIP-7



Symbol	Dimension in Millimeters		Dimensions in Inches	
	Min	Max	Min	Max
A	9.017	10.160	0.355	0.400
B	6.096	7.112	0.240	0.280
C	-----	5.334	------	0.210
D	0.356	0.584	0.014	0.023
E	1.143	1.778	0.045	0.070
F	2.337	2.743	0.092	0.108
I	2.921	3.556	0.115	0.14
J	7.366	8.255	0.29	0.325
L	0.381	------	0.015	--------

Revision History

Rev.	Date	Change Notice
00	4/10/2013	Original Specification