SPECIFICATION

1. DESCRIPTION

The DK912 is a primary side flyback type AC-DC Switch Mode Power Controlling IC. It integrates 700V high voltage power transistor and primary side peak current detecting circuit. It also includes Primary Side Constant Current Regulation, Constant Voltage Control, Self-Power supply circuit and Output cable compensation functions. Because of its highly integrated CMOS circuit design, lots of external components are saved, transformer design is simple, only two windings are needed in transformer for isolated circuit designs.

2. APPLICATIONS

·Battery charger
·Power AC/DC adapters
·STB power supply
·Electromagnetic oven power supply
·DVD/VCD power supply
·Air conditioner power supply
·AC/DC LED driver applications
·TV/Monitor power supply

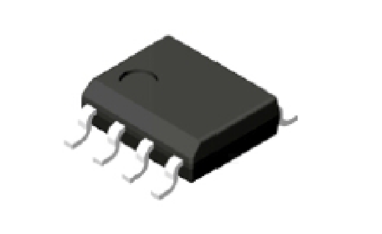
3. MAIN FEATURES

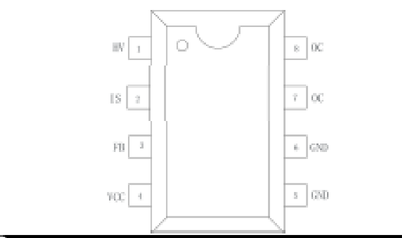
· Build-in 700V high voltage power transistor.
· 85V—265V AC universal input range allows worldwide operation.
· Integrated high voltage constant current starting circuit, no need for additional starting resistance.
· Patent Primary Side Regulation control to simplify the circuit.
· Patent self-power supply circuit design, no need for auxiliary winding in transformer.
· Internal PMW oscillation circuit with Frequency jittering control to keep EMC characteristics.
· Over current, Over temperature, Over voltage and Short Circuit Protection.
· ±2% Voltage Accuracy, ±5%Current Accuracy.
· 4KV Anti-Static ESD test.

4. POWER RANGE

Input Voltage	85-264V AC
MAX. output power	12W

5. CONNECTION DIAGRAM





PIN FUNCTION

Pin NO.	Pin Name	Function
1	HV	Staring pin, Connected with 2.2M resistor to OC pins
2	IS	Connected to ground via resistor, to set the MAX. peak current
3	FB	Primary side feedback control pin.
4	VDD	Power supply pin. Connects a 10uF-47uF capacitor to ground.
5,6	GND	Ground reference
7,8	OC	Drain pin for internal high voltage power transistor.

6. ABSOLUTE MAXIMUM RATINGS

Parameter	Value	Unit
Supply voltage （VDD）	-0.3--8	V
Current of supply voltage	100	mA
Pin voltage	-0.3--VDD+0.3	V
Transistor withstand voltage	-0.3--730	V
Peak current	700	mA
Total power dissipation	600	mW
Operating temperature	-25--+125	℃
Storage temperature	-55--+150	℃
Lead temperature	+280	℃/5S

7. ELECTRICAL CHARACTERISTIC

Parameter	Condition	Value			Unit
		Min.	Typ.	Max.	
Power Supply voltage	AC input: 85V-265V	4	4.7	6	V

Start threshold Voltage	AC input: 85V-265V	4.5	4.7	5.0	V
Restart Voltage	AC input: 85V-265V	3.3	3.6	3.9	V
Stop threshold Voltage	AC input: 85V-265V	6	6.2	6.5	V
Current of power	Vdd=5V, Fb=2V			40	mA
High voltage startup current	AC input: 265V			0.5	mA
Start time	AC input: 85V	--	--	500	mS
BJT Breakdown voltage	Ioc=1mA	700			V
BJT Breakdown current	Vdd=5V			350	mA
IS MAX. working voltage	Vdd=5V	360	400	440	mV
IS MIN. working voltage	Vdd=5V	80	100	120	mV
CV reference voltage	Vdd=5V	2.45	2.5	2.55	V
Working frequency	Vdd=5V	16k		65k	Hz
MIN startup time	Vdd=5V		500		nS
Open circuit protection	Vdd=5V, FB voltage testing		3.7		V
Short circuit protection	Vdd=5V, FB voltage testing		1.3		V
Temperature protection	Vdd=5V	120	125	130	℃

8. OPERATION PRINCIPLE

DK912 controls the output voltage Vout via detecting the voltage of primary side wiring(Vor) in the flyback stage.

$V_{OUT} \approx \frac{V_{OR}}{N} * \frac{R_2}{R_1} - V_d$ (N is Turn ratio of transformer, Vd is voltage of secondary side rectifying diode).

Max. output power is limited by setting the external peak current of IC(Ip max): $Po\max \approx \frac{1}{4} * Ip\max * N * Vout$, so the Po max could be adjusted by N.

When the output is in MAX. status, $Fs\max = \frac{N*Vout}{2*Lp*Ip\max}$, need to make sure it is less then 65kHz, accordingly to this, can get the min. Lp value: $Lp\min = \frac{N*Vout}{2*Fs\max*Ip\max}$ $= \frac{16*5}{2*65k*600mA} = 1mh$

8.1 Start Up

With its internal high voltage constant current driving circuit, external VDD capacitor would be charged when power on, when the voltage of VDD reaches 5V, starting up process finished and the IC enters into soft start stage.

8.2 Soft Start

1ms after starting up, the IC works at 32khz, peak current is $\frac{1}{2} * Ip\max$

256uS after starting up delayed, begins to detect FB voltage.

8.3 FB detecting

In the flyback stage, output voltage was mapped to FB pin via the Coupling relationship of primary side or secondary side winding. IC detects and controls the output current and voltage via detecting the FB voltage. When it detects the FB>0.7V, it would judge flyback beginning and sample the FB voltage. As to avoid mistakes of taking the leakage voltage, it would begin sampling 2.5us later. The sampled voltage of FB would be compared with the internal reference voltage of 2.5V, error amplifier controls the primary peak current Ip with its output control, so that to adjust output voltage and current.

8.4 Constant Current output control

When loading is more then its maximum output power, output voltage decreases, FB's voltage is less then 2.5V, IC will work at constant current status. Output current $Io \approx \frac{1}{4} * Ip\max * N$, IC's working frequency $Fs = \frac{N * Vout}{2 * Lp * Ip\max}$. As per the loading keep on increasing, output voltage decreases and the Fs decreases. When the output voltage is less the half of the normal value, IC would enters into protection status.

8.5 Constant Voltage output control

When the loading is less then its maximum output power, IC will work at constant voltage status, it will control the peak current and working frequency accordingly loading status. If less then 65kHz, the working frequency of IC $Fs = \frac{N * Vout}{2 * Lp * Ip\max}$.

While loading increases, Ip increases and Fs decreases accordingly. And While loading decreases, Ip decreases and Fs increases accordingly, IC works at PWM mode.

When loading decreases and the frequency reaches 65khz, it will work on this fixed frequency, IC works at PWM mode. f loading keeps on decreasing or to empty load, IC enters into jump off mode so that to keep low power consumption.

8.6 Peak Current Protection

Ris (resistor connected with PIN IS to ground) is resistor of current sampling, it is used for setting the maximum output current of the power supply. Ip max=400mV/Ris. Typical value of Ip max is 660mA.

8.7 Self-Power Supply Circuit (National patent owned)

There is self-power supply circuit inside the IC, which can control the VDD voltage at about 4.7V for the electricity consumption of the IC itself. So that can save external winding power supply.

8.8 Cable compensation

With Cable compensation circuit, can decrease the output voltage error caused by cable resistance in different loading. Cable compensation current Icomp increases when loading increases, maximum value is 12uA.

For three windingly application, cable compensation voltage is $2*\frac{N_S}{N_A}*I_{COMP}*R_{FB2}$

For two windingly application, cable compensation voltage is $2*\frac{N_S}{N_P}*I_{COMP}*R_{FB2}$

8.9 Abnormal Voltage Protection

Whenever the power voltage (Vcc) abnormally exceeds 6.2V, the controller would stop operation and enters into stop status.

8.10 Abnormal FB voltage Protection

If secondary side is of open circuit, Vor keeps on increasing. When FB pin's detected voltage is more then 3.7V, the IC enters into protection status.
After power on, if FB resistor is detected to be disconnected, IC will enter into protection status.

8.11 Transistor Over Voltage Protection

Whenever more then 600V is detected on the power transistor, IC will enter into protection status.

8.12 Short Circuit Protection

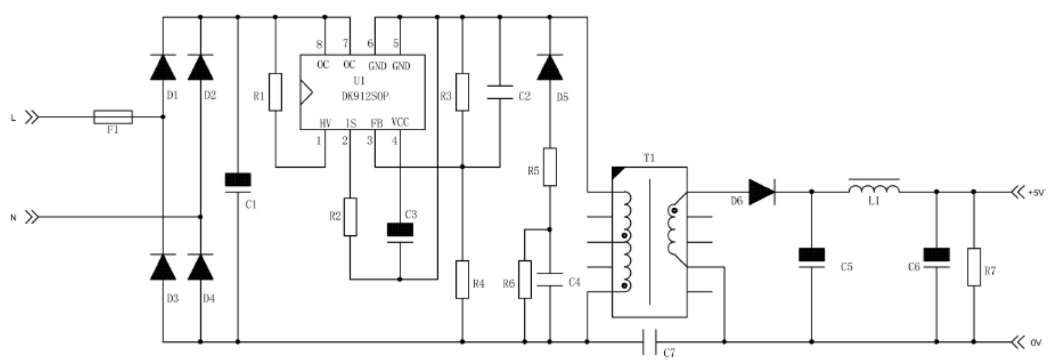
As to protect the secondary side, whenever the lower then 1.3V is detected on FB and lasting time is more then 8ms, IC will enter into protection status.

8.13 Over Temperature Protection (OTP)

When the controller detects the IC temperature exceeds 130℃, OTP is activated. It stops the switching operation immediately and enters into the stop status. The controller will restart to switching operation when the temperature falls down.

9. TYPICAL APPLICATION SAMPLE 1

5V 2A with two winding wires



9.1 Components list

NO.	NAME	SPEC. / MODEL NO.	POSITION	USED QTY	REMARK
1	Fuse	F2A/AC250V	F1	1	
2	rectifier	1N4007	D1~D4	4	
3	Diode	FR107	D5	1	
4	Diode	SR540	D6	1	
5	Electrolytic capacitor	15uF/400V	C1	1	
6	Electrolytic capacitor	22uF/16V	C3	1	
7	Electrolytic capacitor	1000uF/16V	C5	1	
8	Electrolytic capacitor	1000uF/16V	C6	1	LOW ESR
9	Inductor	10uH/2.5A	L1	1	
10	Ceramic capacitor	2G103	C4	1	
11	Y capacitor	102	C7	1	
12	Capacitor	10Pf 25V	C2	1	
13	Resistance	2.2M	R1	1	
14	Resistance	100K	R6	1	
15	Resistance	47Ω	R5	1	
16	Resistance	0.5	R2	1	1% accuracy
17	Resistance	250K	R4	1	1% accuracy
18	Resistance	8K	R3	1	1% accuracy
19	Resistance	1K	R7	1	
20	IC	DK912 (SOP-8)	U1	1	
21	Transformer	EE19	T1	1	

9.2 TRANSFORMER DESIGN

9.2.1 Parameter confirmation: confirm the below parameter before transformer design

(1) Input voltage range:AC85V-265V

(2) Output Voltage and current: for example DC5V 2A, MAX. switch mode frequency: 65khz, MAX. duty cycle: 50%

9.2.2 Core selecting

(1) Input power calculation

P=Pout/η (η is the efficiency of the power supply, take it 0.75 for example), Pout=Vout*Iout=5V*2A=10W, so P_{in}=10/0.75=13.3W.

(2) Choose the core:

Checking via supplier or the correlative chart can know that EE19 core is suitable for 13.3W power supply. And Ae=23mm^2

9.2.3 Turn ratio of transformer

Flyback voltage of transformer (V_{or}) is normally set to be 60V—120V, and 80V is recommended normally.

$$N = \frac{Vor}{Vout} = \frac{80V}{5.5V} \approx 15$$

9.2.4 Resistor Rs calculation

As mentioned above, $I_P = \frac{2*Po\max}{V_{IN}*T_{ON}*Fs\max*\eta} = \frac{2*10W}{100V*8us*60K*0.75} \approx 560mA$,

$Ip\max = \frac{400mv}{Rs+0.1}$ => $Rs \approx 0.6ohm$, in actual testing, we take RS≈0.56ohm, so that output is 10W.

9.2.5 Inductor calculation

$P_{in} = \frac{1}{2}L*I_P^2*Fs$, so $L = \frac{2*Po\max}{I_P^2*Fs\max*\eta} = \frac{2*10W}{0.56A^2*60K*0.75} \approx 1.4mH$

9.2.6 Number of the original(input) turns (Np)

$\lambda = N_P*A_e*B$, $\lambda = L*I_P$, so $N_P = \frac{L*I_P}{B*A_e}$

Because the saturation magnetization of Ferrite material is about 0.4T, the designed Magnetic flux density in transformer should be no more then 0.4T. However, Single-ended Flyback circuits works in the first quadrant of B-H, and residual magnetism of the core is about 0.1T, so the maximum working magnetic flux density should be 0.4-0.1=0.3T. According to formula $B_{max} = (I_P*L_P)/(N_P*A_e)=0.3T$, here below takes 0.25T for calculation, and A_e in EE19 transformer is 23mm², so we can get that

$N_P = I_P*L_P/B_{max}*A_e = 560mA*1.4mH(/0.25T*23mm^2) \approx 136$

We take 136 turns in actual use.

9.2.7 Number of the output turns (Ns)

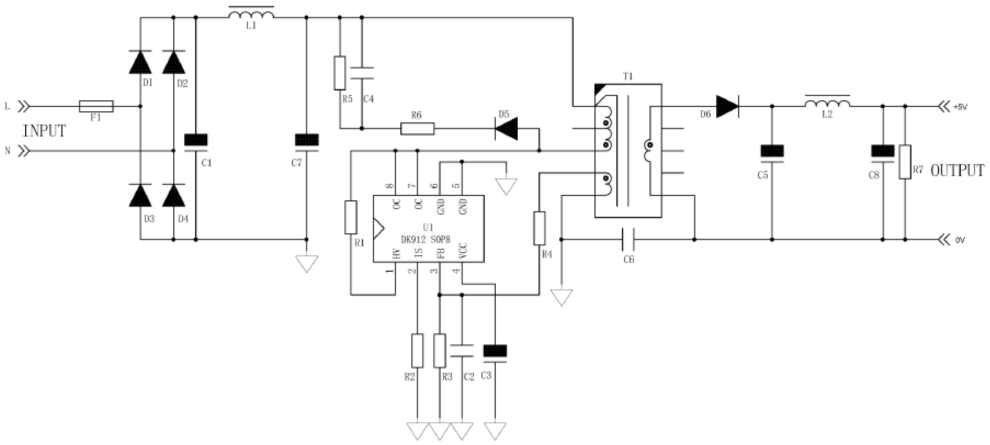
$N_s = N_p/N = 135/15 = 9$

9.2.8 Leakage inductance of a transformer

It is suggested to use P/S/P way to wind the transformer so that to reduce the leakage inductance.

10. TYPICAL APPLICATION SAMPLE 2

5V 2A with three winding wires



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6	Electrolytic capacitor	22uF/16V	C4	1	
7	Electrolytic capacitor	1000uF/10V	C5	1	
8	Electrolytic capacitor	1000uF/10V	C8	1	
9	Inductor	2mH/EMI	L1	1	
10	Inductor	10uH/2.5A	L2	1	
11	capacitor	103/250V	C4	1	
12	Y capacitor	102	C6	1	
13	capacitor	10pF / 25V	C2	1	
14	Resistance	100K	R5	1	
15	Resistance	47Ω	R6	1	
16	Resistance	2.2M	R1	1	
17	Resistance	0.5	R2	1	1% accuracy
18	Resistance	10K	R4	1	1% accuracy
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$P_{in} = \frac{1}{2} L * I_P^2 * Fs$, so $L = \frac{2 * Po\max}{I_P^2 * Fs\max * \eta} = \frac{2*10W}{0.56A^2 * 60K * 0.75} \approx 1.4mH$

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We take 135turns in actual use.

10.2.7 Number of the output turns (Ns)

$N_s = N_p/N = 135/15 = 9$

Auxiliary winding should be of same terns as secondary winding turns, and next to secondary winding.

10.2.8 Leakage inductance of a transformer

It is suggested to use P/S/P way to wind the transformer so that to reduce the leakage inductance.

11. SPECIAL NOTICE FOR PBC LAYOUT DESIGN

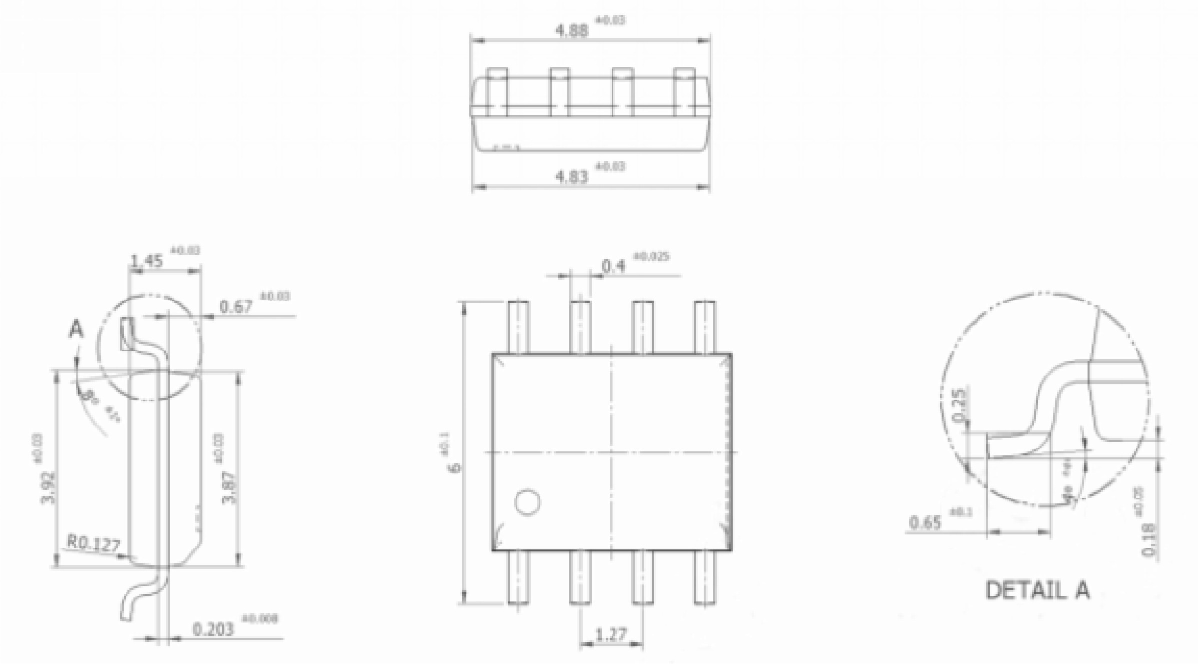
11.1 Heat dissipation: A good estimate is that the controller will dissipate the output power. So enough cooper area connected to the OC pins and tin-plating IS necessary to provide the controller heat sink. Also this part is with signal, EMC/EMI parts should be away from this area.

11.2 The OC pins is high voltage part of the IC, peak voltage is as high as 600V, so it should be at least 1.5mm far away from the low voltage part in the PCB as to avoid circuit breakdown and discharging. Better to open 1mm hole on PCB between pin 5&6 with pin 7&8.

11.3 Leakage inductance of a transformer

It is suggested to use P/S/P way to wind the transformer so that to reduce the leakage inductance. Also the value of leakage should be controlled within 5%

12. MECHANICAL AND PACKING INFORMATION (SOP-8)



Packing: 2500pcs/reel