PC power 线路分析及计算技巧

实例：1. Pout = 300W   Pin = 90V - 264V   η = 65%. NO PFC

F = 70K   PF = 0.65

2. output: +12V/16A.   +5V/30A   +3.3V/20A   -12V: 0.5A

-5V/0.5A

3. 已知变压器：Np = 48T.

NS(+12V) = 9T

NS(+5V) = 4T

NS(+3.3) = 3T

NS(-12V) = 11T

4. 线路拓扑结构采用 Forward 线路形式.

下面是对各部分电路的分析和计算：

一、输入回路：

1. FUSE：

$\because U I_{in} \cos\theta\,\eta = P_{out}$

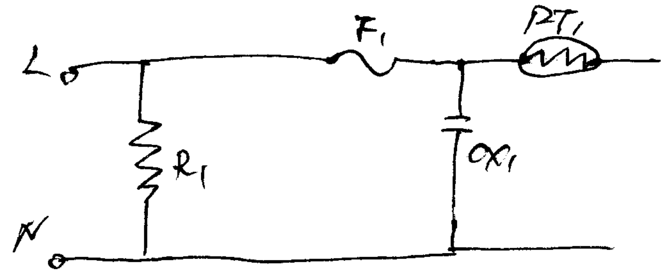
$$I_{in} = \frac{P_{out}}{U\cos\theta\,\eta}$$

若：PF = 0.65
即 $\cos\theta = 0.65$ 时：$I_{in\,max} = \frac{500W}{90V \times 0.65 \times 0.65} = 7.8A$

2. 安规放电电阻计算：

放电公式：$V_t = V_0 e^{-\frac{t}{\tau}}$　　安规要求在1秒钟内 $V_t = 37\% V_0$

EMI选型 $CX_1 = 1uF$



又 $\because RC = \tau$
$t = 1$秒

$\therefore V_t = V_0 e^{-\frac{t}{\tau}}$

$= V_0 e^{-\frac{1}{R_1 C_{X1}}}$

$37\% V_0 = V_0 e^{-\frac{1}{R_1 \times 1uF}}$

$\ln 0.37 = -\frac{1}{R_1 \times 1uF}$

$-1 = \frac{-1秒}{R_1 \times 1uF}$

$R_1 = 1M\Omega$

$\therefore R_1$ 选用 1/2W, 1MΩ

3. Thermistor：

若spec要求浪涌电流 < 60A

$\therefore R_{therm} = \frac{V_{in}}{60A} = \frac{264V}{60A} = 4.4$

uKCap:

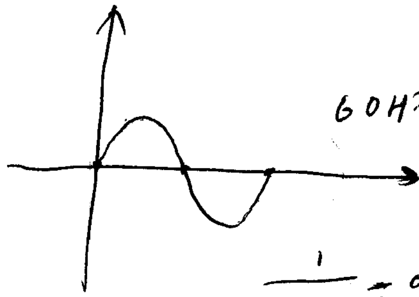
$$C = \frac{It}{\Delta V}$$

C: 电容器. uF

I: 直流负载电流

t: 电容器能提供的电流时间 ms

ΔV: 容许的峰对峰纹波值. V.



$\frac{1}{60} = 0.016S$.

半周期 = 8ms

若: $P_{out} = 300W$ $\eta = 65\%$. $\Delta V = 30V$. $t = 8mS$.

$$P_{in} = \frac{300}{65\%} = 460W$$

$$I = \frac{P_{in}}{E} = \frac{460}{2(90V \times \sqrt{2})} = 1.80A$$

$$\therefore C = \frac{1.80A \times 8mS}{30V} = 480uF$$

∴ C6、C7 为 960uF. 可选: 1000uF. 亦可选 820uF.

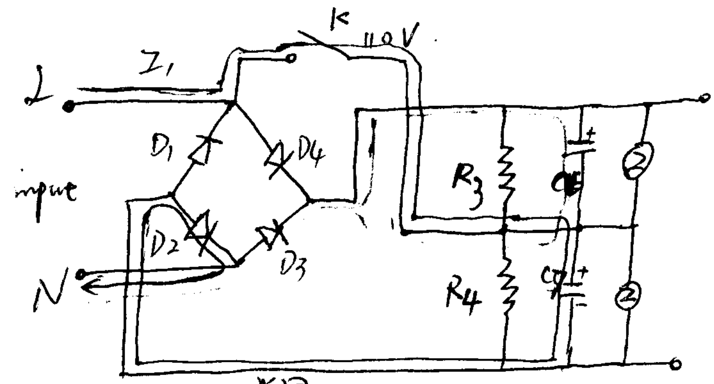
5. 输入整流器：（input Rectifiers）

① 最大顺向整流容许值：2倍计算之稳态电流值。

② 峰值逆向电压阻隔值：600V — 800V。

③ 突波电流容许值。

6. 倍压整流电路：

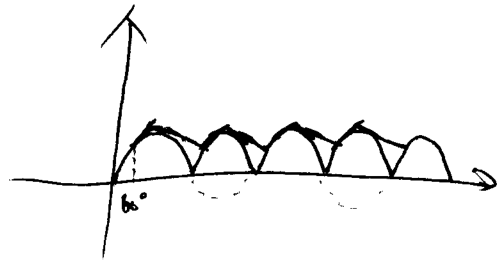


正半周

K 断时 Z1 经 K，C7，D2，到 N。

~~K on 时~~

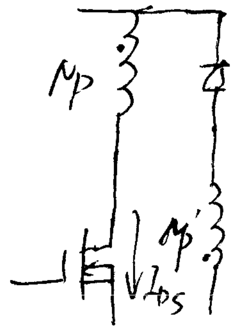
K 断时，Z2 负半周经，D3，C6，K 到 L。



POWER MOSFET CHOOSE

①. CONSIDER DRAIN – SOURCE BREAKDOWN VOLTAGE BVDSS

$$BV_{DSS} > V_{dc(max)}\left(1+\frac{N_p}{N_p'}\right)$$



$$BV_{DSS} > 2V_{dc(max)}$$

$$V_{DS} > 2V_{dc(max)}$$

②. $I_{DS} > \frac{D_{max} I_{o(max)}}{N}$

③. $I_{DM}\ (I_{DS\,peak}) > \frac{I_{o(max)} + I_{o(min)}}{N} + \frac{V_{dc(min)} D_{max} \cdot T_S}{L_p}$

④. $R_{DS(ON)}$

以PE35例: $V_{DS} > \left(1+\frac{N_p}{N_p'}\right) \times V_{dc(max)}$

$= 2V_{dc(max)}$

$= 2 \times 370\ V = 640V$

将 Power 折算到 +12V output.
∴ $I_{omax} = \frac{300W}{12V} = 25A$

$$I_{DS} > \frac{D_{max} \cdot I_{omax}}{N} = \frac{0.45 \times 25A}{\frac{48}{9}} = 2.12A$$

$$I_{DM} > \frac{I_{(max)} + I_{o(min)}}{N} + \frac{V_{dc(min)} D_{max} \times T_S}{L_p}$$

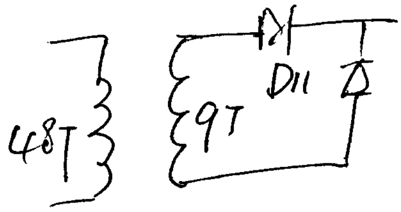
$$= \frac{25 + 0.5}{5.3} + \frac{130 \times 0.45 \times \left(\frac{1}{70 \times 10^3}\right)}{5mH}$$

+12V 绕阻为 5mH

$= 4.96A$

∴ CHOOSE : 500V, 15A FUJI 2SK1016 * 2 $R_{DSON} = 5.5$

put circuit:



1. output Diode:

A. FORWARD DIODE

① $V_{RRM} > \frac{N_S}{N_P} * V_{dc}$

② $I_o(avg) = I_o(max) D_{max}$

③ $I_{FSM} > I_o(max) + I_o(min)$

B. FREE-WHEELING DIODE.

① $V_{RRM} > \frac{N_S}{N_P} \times V_{dc}(max)$

② $I_o(avg) > (1 - D_{min}) I_o(max)$

③ $I_{FSM} > I_o(max) + I_o(min)$

以PC35-040为例: $D_{max} = 0.45$. $D_{min} = 0.2$ $N_P = 48T$

+12V/16A $V_{DC}max = 264 \times \sqrt{2} \approx 370V$. $N_S(+12V) = 9T$

∴ ① $V_{RRM} > \frac{N_S(+12V)}{N_P} \times V_{dc}(max)$

$> \frac{9}{48} \times 370V$

$> 70.0V$.

② $I_o(avg) > I_o(+12V) D_{max}$

$> 16A \times 0.45$

$> 7.2A$

③ $I_{FSM} > I_{o(max)} + I_{o(min)}$

$> 16A + 0.5A$

$> 16.5A$

B: FREE - WHEELING DIODE (+12V)

$$V_{RRM} > \frac{N_s}{N_p} \times V_{dc}$$

$$= \frac{9}{48} \times 370V$$

$$= 70V$$

$$I_{o(avg)} > (1 - D_{min}) I_{o(+12V)}$$

$$= (1 - 0.2) \times 16A$$

$$= 12.8A$$

$$I_{FSM} > I_{o(max)} + I_{o\,min}$$

$$= 16 + 0.5A$$

$$= 16.5A$$

所以可选用 $V_{RRM} = 200V$ $I_{o(avg)} = 30A$

$I_{FSM} = 50A$.

CAPACITOR :

1. $C_o \geq \frac{T_s^2 \times V_o}{8L_o \times \Delta V_o(max)}$

2. CHOOSE CAPACITOR RATED VOLTAGE

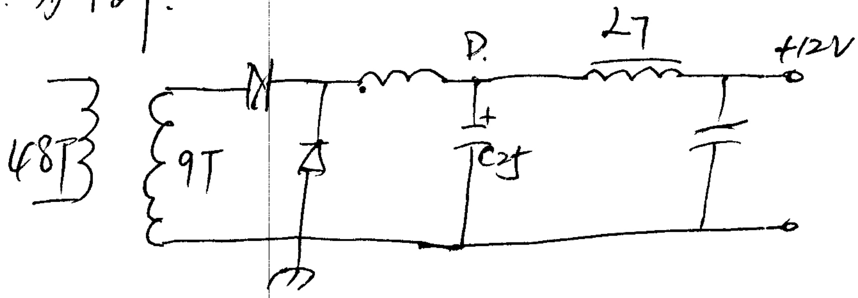
W.V. > Vo.

3. $I_{ripple}(rms) > \frac{\Delta I_L}{2\sqrt{3}} = \frac{2I_o(min)}{2\sqrt{3}} = \frac{I_o(min)}{\sqrt{3}}$

4. ESR

$ESR(max) < \frac{\Delta V_o(max)}{\Delta I_L} = \frac{\Delta V_o(max)}{2I_o(min)}$

以 PC35-042 +12V output 为例:



① $C_o \geq \frac{T_s^2 \times V_o}{8L_o \times \Delta V_o}$

$\therefore C_{25} \geq \frac{(\frac{1}{70\times10^3})^2 * 12V}{8\times1.3\times10^{-6}\times120\times10^{-3}} \times (1-0.2)$

$= \frac{1.96\times10^{-10}\times12\times0.8}{8\times1.3\times10^{-6}\times0.12}$

$= 15.1\times10^{-4}\ F$

$= 1510\ uF$

③

$$I_{ripple,rms} > \frac{\Delta I_L}{2\sqrt{3}} = \frac{I_{o(max)}}{\sqrt{3}} = \frac{0.5A}{\sqrt{3}} = 0.3A \quad ?$$

~~$i_{ripple} = I_o \times \sqrt{D}$~~

~~$= 16A \times \sqrt{0.45}$~~

~~$= 10.77A$~~

④. ESR :

$$ESR(max) < \frac{\Delta V_{o(max)}}{\Delta I_L} = \frac{\Delta V_{o(max)}}{2 I_{o(min)}} \quad ?$$

$$= \frac{120mV}{2 \times 0.5A} = 120m\Omega$$

∴ PC35 选用：2200uF 16V. or 25V.

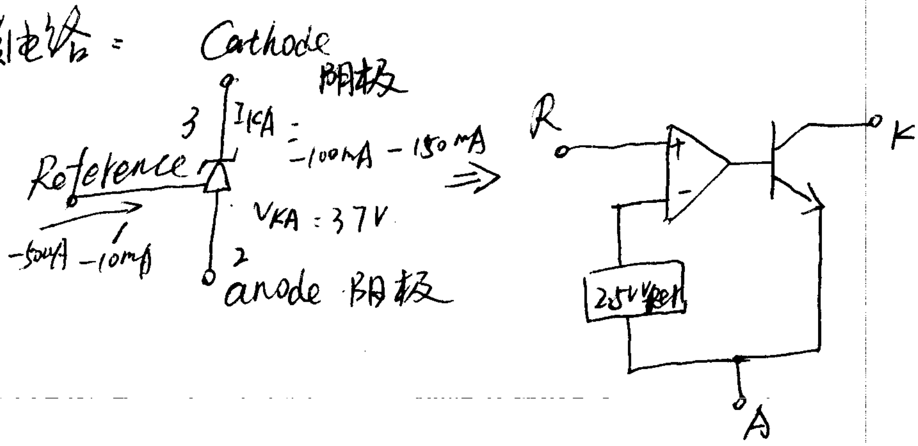
100k 20°C

2200uF 16V: Ripple current : 1.45A impedance : 0.15 (ESR)

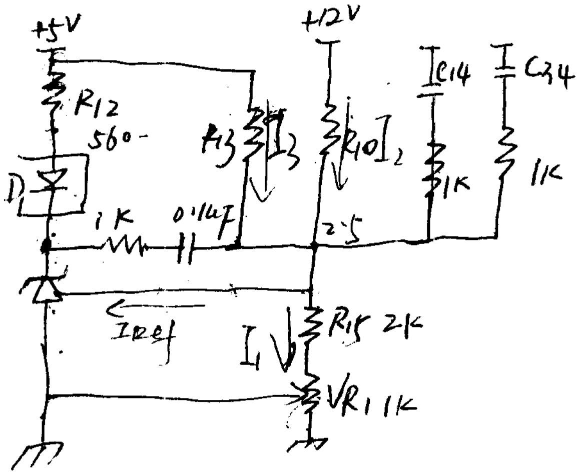
2200uF 25V: Ripple Current : 2.47A impedance : 0.027 (ESR)

∴ 综合上面计算选用 25V. 2200uF. ELE Cap.

回授电路：



实例：



$$V_o + V_d = \frac{V_{in\,min} N_s}{N_p} \cdot D$$

由于 $V_{ref} = 2.5V$，所以 $R_{15} + VR_1$ 通常可取2.5K，那么 $I_1 = \frac{2.5V}{2.5K} = 1mA$，

∵ I_{ref} 电流通常为2-4uA 所以 $I_3 + I_2 = I_1$

取 $I_3 = I_2 = 50\% I_1$

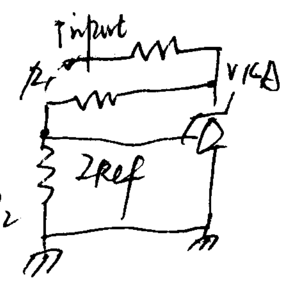
$$\therefore R_{10} = \frac{12V - 2.5V}{0.5mA} = 19K$$

$$R_{13} = \frac{5V - 2.5V}{0.5mA} = 5K$$

若：$I_{KA} = 5mA$，$V_{KA} = 2.5V$，$V_{D1} = 1V$

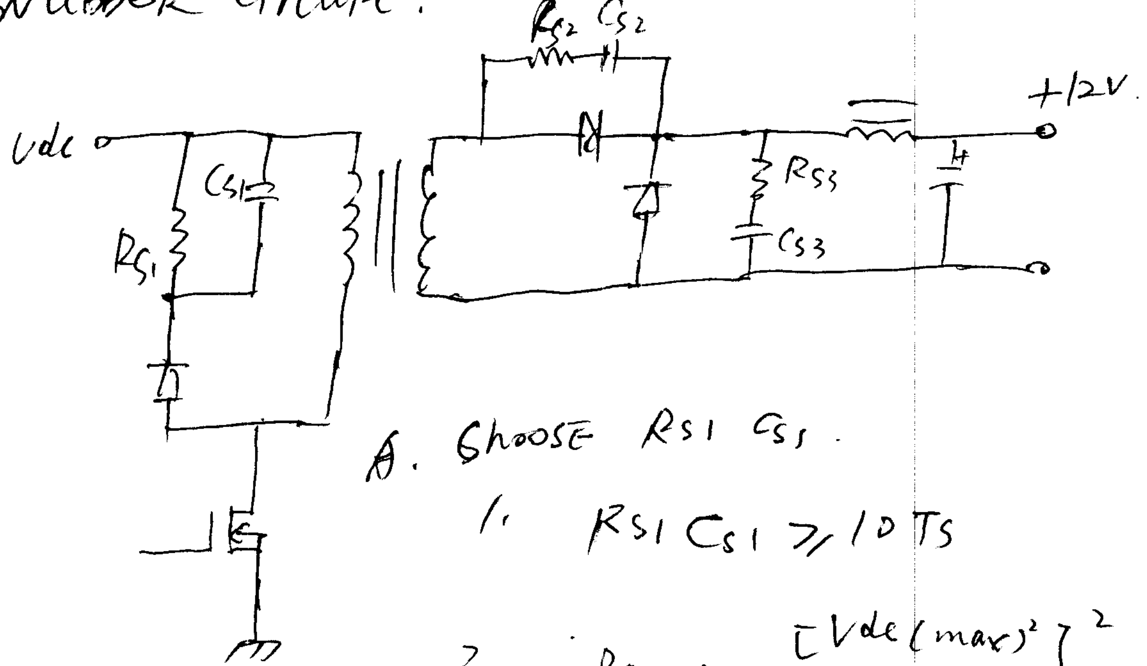
$$R_{12} = \frac{1.5V}{5mA} = 300\Omega$$

若：$I_{KA} = 10mA$ ∴ $R_{12} = 150\Omega$



$$V_{KA} = V_{ref}\left(1 + \frac{R_1}{R_2}\right) + I_{ref} \times R_1$$

SNUBBER Circuit :



A. Choose R_{S1} C_{S1}.

1. $R_{S1} C_{S1} \geq 10 T_S$

2. $P_{S1} = \frac{[V_{dc(max)}^2]^2}{R_{S1}}$

B. Choose R_{S2}, R_{S3}

$$R_{S2}, R_{S3} \leq \frac{V_{RRM}}{I_{RM}}$$

$$I_{RM} = \frac{2 Q_{rr}}{t_{rr}}$$

$Q_{rr} = C_j V$: STORED CHARGE IN THE JUNCTION CAPACITANCE

t_{rr}: DIODE RECOVERY

C. CHOOSE C_{S2}, C_{S3}

$$C_{S2} C_{S3} \geq \frac{L_{LS} I_{RM}^2}{V_{RRM}^2}$$

D. RS2, RS3 RATing

$$P_{RS2} ; (P_{RS3}) = \frac{F_S \times C_{S2} \times V^2}{2}$$