Components that determine the life of the power supply explained

Ⅰ、to determine the life of the power supply components

① Electrolytic capacitors

The sealing part of electrolytic capacitors will leak out the vaporised electrolyte, and this phenomenon will be accelerated as the temperature rises, and it is generally believed that the leakage rate will increase up to two times for every 10℃ rise in temperature. Therefore, it can be said that the electrolytic capacitor determines the life of the power supply unit.

② Fan

Depletion of lubricating oil for ball bearings and bearings, and wear and tear of mechanical device parts accelerate the aging of fans. In addition, since electrolytic capacitors and other components have been used in the drive circuits of DC fans in recent years, it is necessary to consider the life of the circuit components as well.

③ Optocoupler

The current transfer ratio (CTR; Current Transfer Ratio) decreases over time, and as a result, the current of the light emitting diode (LED) increases, sometimes reaching the maximum limiting current and causing the system to go out of control.

④ Switch

Most switching power supplies are equipped with a rectifier circuit of the capacitor input type, which generates an inrush current when the power supply is energised, leading to fatigue of the switching contacts and triggering problems such as increased contact resistance and adsorption. Theoretically, the number of switching cycles during the expected life of the power supply is about 5,000.

⑤ Inrush Current Protection Resistors, Thermal Power Resistors

In order to resist the inrush current generated when the power supply is turned on, designers use resistors in parallel with SCRs and other components. The power peak at the time of power-on can be tens to hundreds of times the rated value, resulting in thermal fatigue of the resistor, causing a circuit breakage. Thermal fatigue also occurs in thermal power resistors in the same situation.

Ⅱ、 Evaluation and calculation of the life of each component

① Electrolytic capacitors

1、Life performance

The end of life of electrolytic capacitors in the form of wear and tear failure, the main factors determining the life of the electrostatic capacity, the tangent of the angle of loss (tan δ), leakage current and so on. Over time, the electrostatic capacity decreases and tan δ increases. Leakage current has a tendency to increase when voltage is applied, so it has little effect on the life of the load.

2、Determination of life

The percentage is used to indicate the change rate of electrostatic capacity relative to the starting value, generally reaching -20% or less is the end of life. tan δ value exceeds the specified value when the life of the load is over. Leakage current has a tendency to increase under zero load, similarly, the life span ends when it exceeds the specified value.

3、The main reasons affecting the life

The main reason for the deterioration of the characteristics mentioned earlier is the electrolyte. As the temperature rises, the electrolyte vaporises and leaks outwards through the sealing part of the capacitor, and the electrolyte inside decreases continuously. As the amount of electrolyte decreases, the tan δ gradually increases and, as a result, the heat generation generated when the pulse current is routed increases, which further accelerates the degradation process.

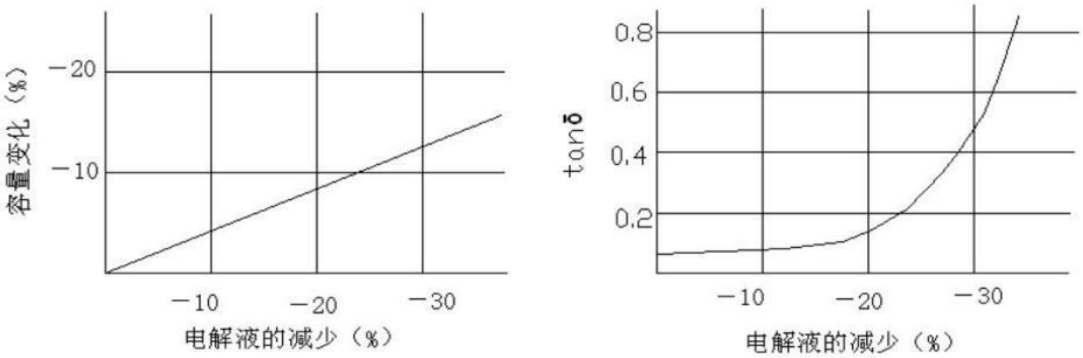


图4（左图）电解液的减少与容量变化
图5（右图）电解液量与tanδ变化

This relationship is shown in Fig. 4 and Fig. 5.

4. Life projection

$$L2 = L1 \bullet 2^{\frac{T1-T2}{10}}$$

左这里，L1=温度 T1 时的寿命
L2=温度 T2 时的寿命
T1=最高保证温度或测试温度＋脉冲发热温度
T2=推算寿命时的环境温度＋脉冲发热温度
要求 T1 ＞ T2

The approximate life of aluminium electrolytic capacitors can be deduced from the ambient temperature and the self-heating temperature caused by pulse current. The following equation shows the relationship between life and ambient temperature.

When determining the warming value of pulse heating, it is necessary to avoid other heat radiation. In addition, small electrolytic capacitors are very susceptible to heating, so it is best to measure the surface temperature.

① Photocoupler

GaAs-based infrared light-emitting diodes often use a photocoupler. The degradation of the luminous efficiency of these LEDs leads to a decrease in the CTR (current transfer rate), and other forms of CTR deterioration include stripping of the photoconductive resin on the chip surface. The higher the temperature, the faster the CTR decreases. Also, the higher the diode current, the faster the CTR drops. Figures 6 and 7 illustrate the relationship between these factors.

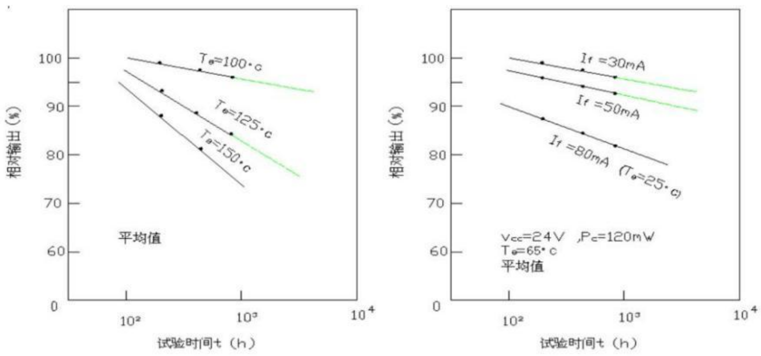


图 6（左上图）保存温度对 CTR 的径时变化
图 7（右上图）动作试验与 CTR 的径时变化

The time it takes for the CTR to fall to 50% of its starting value is called the half-life. This is used as a cut-off value in power circuit statistics, so it can be assumed that the half-life is the life time. Typically, the half-life is 50,000 to 100,000 hours, but all optocouplers have a lifetime value as shown in Figure 8, so it is best to confirm this before making a lifetime assessment.

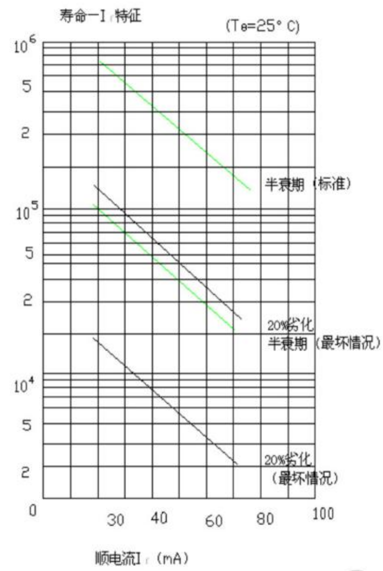
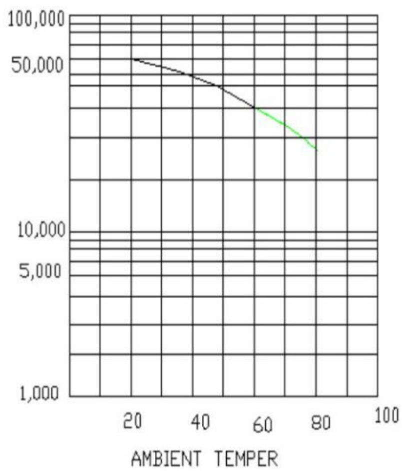


Fig. 8

② Fans

The life of the fan is affected by the degree of wear of the bearing and ball bearing. The bearing part heats up as it rotates, and the fan itself can provide some cooling, but it does not solve the root cause of the heat problem. Measure the temperature rise in the bearing area. The lower the temperature rise, the better the quality, and from there, select the right manufacturer.

The drying up of the lubricant in the bearing area and the wear and tear of the bearings lead to a decrease in the number of revolutions and an increase in noise, which accelerates the end of the life of the machine. The standard for the reduction of the number of revolutions varies from manufacturer to manufacturer, but generally 3 to 5% of the starting value is the upper limit. Life expectancy decreases as the temperature rises. A typical DC brushless motor has a life of about 40,000 hours at 40° C, and an inexpensive metal bearing fan has a life of about 10,000 hours. Figure 9 shows the characteristic values for fan life. In addition, the life of a DC fan is affected by the innards, the motor drive circuit. Aluminium electrolytic capacitors are often used in fans, so it is necessary to disassemble the capacitors for inspection (105° C for aluminium electrolytic).



*虚线部分根据球形进行推算

图9 DC无风扇的寿命特性

③ Anti-surge resistor, thermistor

Resistors

Resistors are highly stable, with a failure rate of less than 1FIT, and have an extremely long life, so there is no need to pay special attention to them during normal use.

Components with surge power, such as resistors, used in inrush current protection circuits are subject to thermal fatigue due to on-off cycling, resulting in breakage. The relationship between surge power, duration and number of cycles is as follows.

The surge resistance characteristics of an attenuated waveform with a load are shown in Fig. 13. Substituting the peak voltage (Vp) of the largest first waveform into equation (7) yields Vrms, which is then substituted into equation (8) to find the rated power multiplier. Both these values and the decay time constant r apply to Fig. 13. The inside of the curve is the safety zone. With ordinary Nichrome wire (surge resistant), approximately 30,000 surges can be withstood.

The time constant is the value of time when the effective value of the decaying waveform drops to 0.368 times the first waveform, so its value is generally obtained from a photograph of the

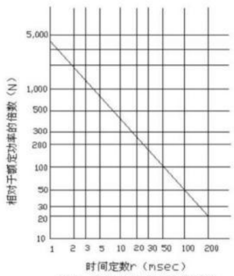


图12 绕线电阻器的耐浪涌特性

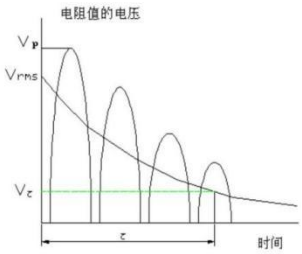


图13 突入电流防护电阻浪涌电压（功率）的衰减波形

waveform on the resistor value.

$$V_{rms} = V_p / \sqrt{2} \qquad (7)$$

$$N = \left(\frac{v_{rms}}{R}^2\right) / W \qquad (8)$$

R：电阻值 ，W：额定功率

Thermistor

① Lifetime Performance

The thermistor is used as a component of the inrush current protection circuit in power supplies with a small capacity (not exceeding 70W). When the power supply is turned on, the current reaches its maximum value, and the thermistor's resistance value decreases as the temperature rises. Typically, the temperature rises to 70 to 90 ° C. Although thermistors are made of heat-resistant materials, thermal fatigue still affects their life. The manufacturer's specification for life is 10,000 cycles of intermittent loading at the maximum allowable current. However, when thermistors are used to protect against inrush currents, the current that passes through the resistor after the power is turned on is 10 to 20 times the maximum allowable current, so the power cycle life is also shortened.

② Life Judgement

When the resistance value changes over time and the rate of change exceeds the specified value, the life of the resistor is terminated. Thermal power resistors are used to protect against inrush currents, and the resistance value gradually increases. Table 3 lists the life performance specifications of thermistors.

表 3 热敏功率电阻器的寿命性能

项　目	规　格	条　　件
断续负荷寿命	电阻变化率±10%	常温常湿，外加最大允许电流 1,000 小时，反复进行 1 分钟 ON—5 分钟 OFF 的循环
连续负荷寿命	电阻变化率±10%	常温常湿，连续外加最大允许电流 1,000 小时。其后放置 25℃环境中 1 小时，再进行检测
潮 湿 放 置	电阻变化率±10%	环境温度 40±3℃，相对湿度 90~95%，放置 1,000 小时。其后放置 25℃环境中 1 小时，再进行检测

③ Reays and Switches

The life of relays and switches is divided into two types: mechanical life and electrical life. The former is determined by the degree of wear and tear of the mechanical parts, and includes such phenomena as reduced switch flexibility and extended relay operating and reset times. The latter is mainly affected by the increase in insulation resistance and contact resistance of the contacts. Of the above forms of deterioration, the most important ones to be aware of are the phenomenon of contact arcing triggered by surge voltages from inductive loads, and contact deterioration triggered by inrush currents. Generally speaking, the higher the switching voltage and current, the shorter the contact life. The lower the power factor, the shorter the life. Figure 14 illustrates the life performance of a relay.

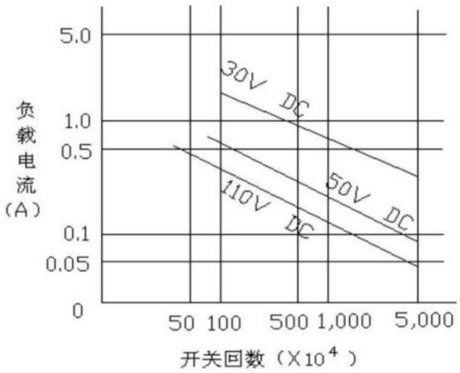


图14　继电器的寿命特性