CHIEFCON ELECTRONIC

Analysis of capacitor filter selection

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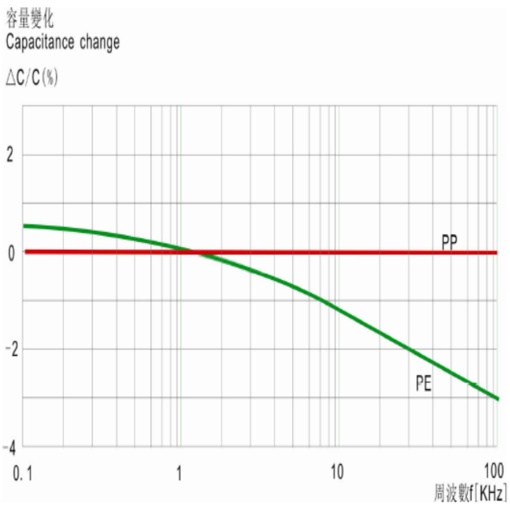
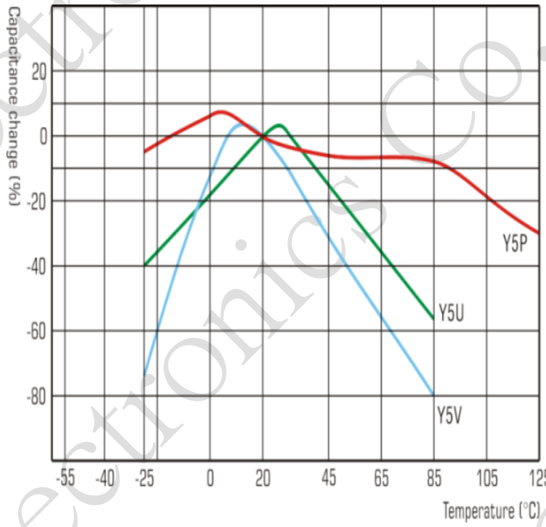
In the face of increasingly complex circuit is applied, the ratio of frequency conversion design is higher and higher, but the past people use filter circuits in EMI/EMC filter design for consideration, and the noise reduction of some frequency bands is the main consideration in this design and different from AC filtered sine wave overlapping high and low interference, the following we currently Y capacitor is used to introduce some applied to the AC filter.

Due to filter design and capacitor impedance are inseparable ，the calculation way is as follows :

$$ESR = \frac{\tan\theta}{wC} \backslash$$

Impedance is also closely related to the material tan θ ，other comparisons are as follows :

Y Capacitor

Type	Film	C/C
DF values	0.1%	2.5%
ESR	Low	Hight
Temperature causes the rate of capacity change	 Mainly by PP curve	 Mainly Y5P, Y5U and Y5V
Capacity	Y1 : 0.00047～0.1µF	Y1 : 1~15000pF
	Y2 : 0.00047~4.7µF	Y2 : 1~15000pF

In general books, the frequency characteristics of a capacitor are explaibed by the C-ESR-ESL general circuit model，see the below to the picture 1.

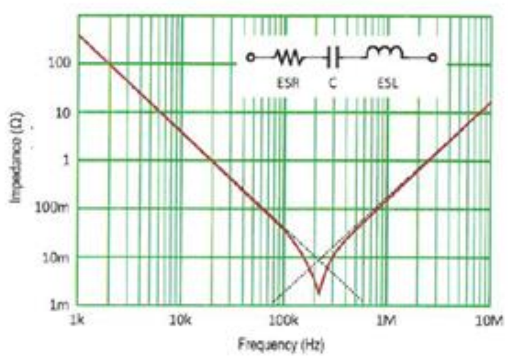


圖 1：電容阻抗圖

Impedance is mathematically expressed as follows :

$$Z(j\omega) = R_{ESR}\frac{1}{j\omega C} + j\omega L_{ESL}$$

The formula above represents a vector, magnitude and phase. If you express it in terms of magnitude and phase, the formula becomes

$$|Z(j\omega)| = \sqrt{{R_{ESR}}^2 + (\omega L_{ESL} - \frac{1}{\omega C})^2}$$

$$< Z(j\omega) = \tan^{-1}\frac{\omega L_{ESL} - \frac{1}{\omega C}}{R_{ESR}}$$

At low frequencies, the impedance and phase are mainly determined by the capacitance value, which we call the capacitance, with a slope of -20dB/dec and an Angle close to -90°. On the contrary, at high frequencies, ESL will dominate the impedance and phase Angle, with a slope of 20dB/dec and phase Angle of nearly 90°. The impedance analyzer is able to scan the impedance at different frequencies and its phase Angle.

The impedance analyzer can be used to measure the impedance diagram similar to Figure 1. In addition to estimating the parameters of the circuit model, it can also observe in which frequency range, how high the impedance provided by the capacitor, so as to facilitate the interpretation and debugging of circuit phenomena.

Inductor

The general lumped circuit model of inductors is shown in Figure 2, where RW is the winding resistance, CS is the stray capacitance of the winding, and RC is the resistance representing the iron loss. In contrast to the capacitor, at low frequency inductance, the higher the frequency, the higher the impedance; At high frequencies, the effect of stray capacitance is obvious, the whole inductor is capacitive, and the impedance decreases with the increase of frequency.

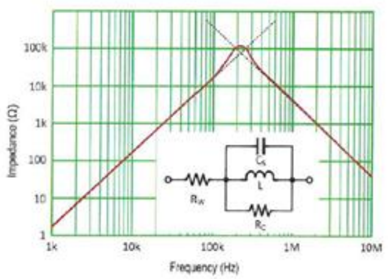


圖 2 : 電感器阻抗圖

LC Filter

Since both the inductor and the capacitor are non-ideal, what will happen if they are applied to an LC filter?

For example, a 53uH ring inductor was used, and the measured data were archived in Excel format. The impedance diagram was first drawn as shown in Fig. 3. Similarly, measure the impedance diagram of a 1uF capacitor, as shown in Figure 4. The effect of the filter can be easily calculated by using the partial pressure theory.

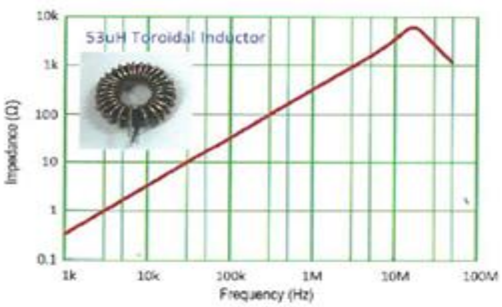


圖 3 : 53uF 環型電感阻抗圖

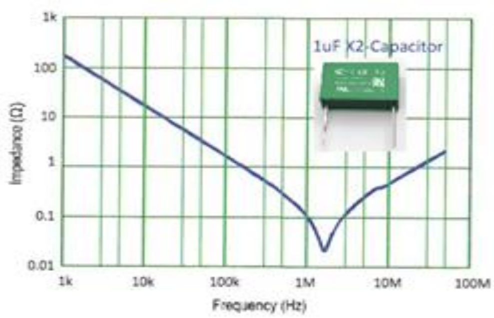
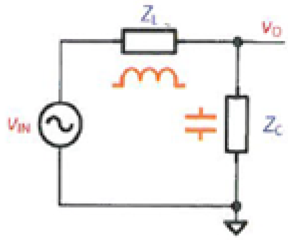


圖 4 : 1uF 電容阻抗圖



$$\frac{v_O}{v_{IN}} = \frac{Z_C}{Z_L + Z_C}$$

圖 5 : 低通濾波器

Therefore, the filtering effect as shown in Figure 6 can be obtained.

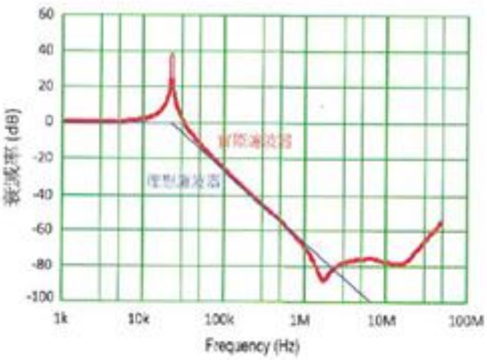


圖 6 : 實際低通濾波效果

An ideal LC filter achieves a good filtering effect with a slope of 40dB/dec after the frequency crosses the corner frequency, but in an actual LC filter, the stray capacitance on the inductor and the series inductance on the capacitor make the filtering effect in the high frequency stage greatly reduced, which the circuit designer must be aware of when selecting components.