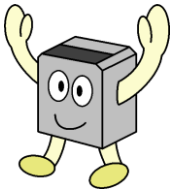
Tips for COIL users (10)



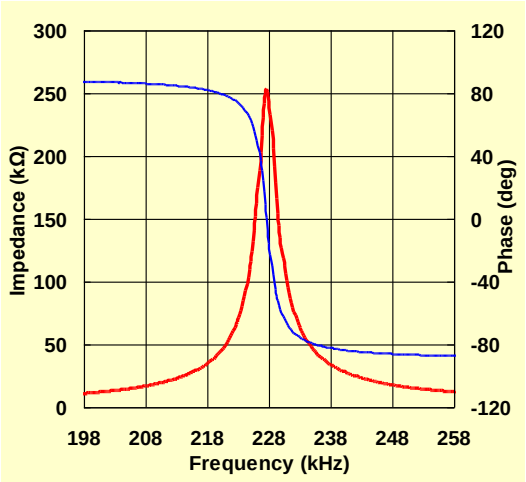
● Introduction

The tenth topic is about "the operation (performance) of coils". There are various modes for the coil operation, so it might be more difficult to understand than other components.

● Utilization of inductance-1：Resonance circuit

Combination of coil（***L***）and capacitor (***C***) generates a resonance. For a parallel resonance circuit, an impedance between terminals reaches a peak at the resonance frequency (For a serial resonance circuit, the value is least).
We can extract a signal of specific frequency or conversely remove it with such phenomenon. In addition, the value of resonance frequency (f_x) is calculated by following formula.

$$f_x = \frac{1}{2\pi\sqrt{LC}}$$



Graph-1 Impedance Characteristics

The parallel resonance circuit was prepared with ***L***=**2.2mH** and ***C***=**220pF**, and the frequency characteristic of impedance (**red**) and the phase (**blue**) was measured as shown in Graph-1. The resonance frequency is almost consistent with the calculated value = 229kHz. In this case, the higher Q is, the sharper the mountain figure of impedance characteristic becomes, also the impedance value at peak increases.

Photo-1 5CHH

When the inductance value changes +/-5.0%, the resonance frequency changes +/-2.5% which is about half of inductance changes.
Therefore, variation of inductance value is important. There are coils of which inductance value was variable. They are called variable coils, and in those days they were often used for high frequency circuit.
Photo-1 is a variable coil of SMD (5CHH type). When we insert the screw driver to the surface groove and turn it, the upper magnetic substance moves up and down. This can change the inductance (approximately +/- a few % to +/- 10 %).
※5CHH　This product is not currently in the lineup.

● Utilization of inductance-2：LC filter

The LC filter is one of application which utilizes the inductance. In the case of filter without the resonance circuit like L.P.F (low-pass filter: Figure-1 is third order L.P.F) and H.P.F, the filter characteristics are determined by inductor and capacitor. Even though the inductance value changes, the effect is not so large as resonance circuit.

Besides, in the case of L.P.F which is used for noise removal of power supply circuit, if we consider the minimum
inductance value of inductor in advance, mostly the large tolerance product can be used.
In this case, theoretically larger inductance is preferred. However, it is adverse effect to produce larger inductance than required, because the actual coils have DC resistance and self resonance frequency.
The inductors used for switching power supply are categorized into LC filter and energy conversion. For the LC filter, only DC resistance is important (high frequency loss can be ignored).

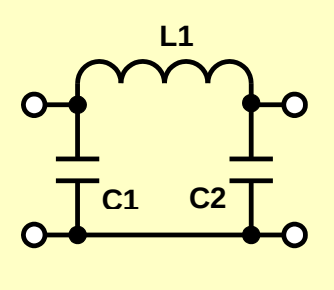


Fig-1 L.P.F.

● Utilization of energy accumulation effect

Like capacitors, coils can accumulate electric energy. It is easy to understand about capacitors because they are voltage element. On the contrary, it is a little bit difficult to understand about coils because they are current element (current mode). To build the switching power supply, following processes are repeated and controlled: 1. turning the power on, 2. supplying current through the coil, 3. accumulating the current, 4. switching to load, and 5. supplying current.

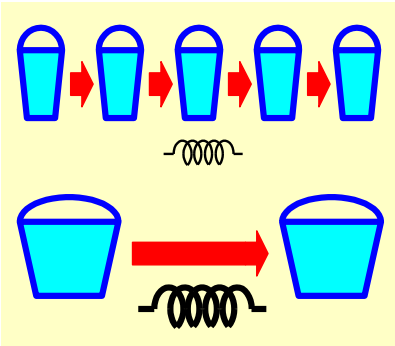


Fig-2
Difference of bucket size

To carry a constant amount of load, there are two kinds of ways: carry with larger container and fewer carrying times, or carry with smaller one and more times (see Figure-2).
Applying this to switching power supply, carrying times are the frequency, and size of container is the inductance. Therefore, when switching frequency is high as a recent trend, inductance used for inductor can be small (small inductor is available). Actual inductances vary depending on output condition).
In the case of switching power supply, the frequency can cover the unevenness of inductance to some extent. Instead, the loss resistance directly effects the power efficiency, so it is important that the coil loss (DC resistance and resistance of operational frequency) is low.

● Utilization of magnetic flux (magnetic coupling)

Coils can work uniquely by using magnetic coupling. Other components such as capacitors can't work like that.
Transformers which some wires are connected are widely used for low frequency wave (mainly electronic circuit) to high frequency (mainly impedance transformation). Photo-2 shows an example of balun transformer for high frequency.
Individual windings are not so important for transformer (in most cases only lowest cost are required). Instead, it is generally important connection state of windings and turn ratio.

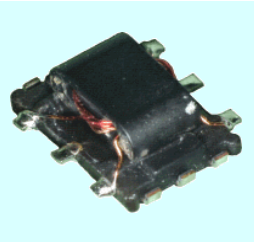


Photo-2 4BMH

Some coils make good use of the magnetic flux; a common mode filter is one of them. Signal (differential signal: blue) flows in a different direction from common mode

noise. With this, two coils are connected to negate the magnetic flux of signal as Figure-3. As the result, the magnetic flux doesn't affect the signal.

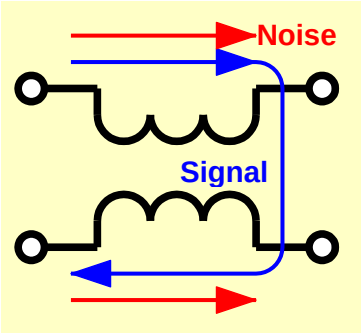


Fig-3
Common mode Coil

In contrast, for common mode noise the magnetic flux operates as the
inductance and works to prevent the common mode noise passing.
The magnetic flux affects only the noise without the signals. This prevents the signal from deteriorating.
Required (=important) electric parameters for coils vary up to the circuit which is used (= coil characteristics which are used). Therefore, we vary the description specified in the general specification depending on the application of product.

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Notes
While we pay sufficient attention to this description in preparing this, if you have any questions or doubts in this description, please contact following address.

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