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An In-depth Analysis of the Core Working Principle — Common Mode Inductors

In-depth Interpretation of Electromagnetic Mechanisms
— from the Expert Perspective of Yuyang Magnetics Co., Ltd

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1. Common Mode Inductor: The Core Component for EMI Filtering

A common mode inductor, also known as a common mode choke, is a key passive component used to suppress common mode electromagnetic interference (EMI). It is widely used at the power input or signal lines of various electronic devices such as switching power supplies, frequency converters, and motor drives.

Pass Differential Mode

Presents extremely low impedance to the differential mode current required for the normal operation of the device, allowing it to pass without loss.

Block Common Mode

Presents extremely high impedance to common mode interference noise present in the circuit, thereby effectively suppressing its propagation.

Essence: Its essence is to use the principle of electromagnetic induction to achieve selective filtering of currents of different natures through a special winding structure.

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2. Principle 1: Low-Impedance Conduction for Differential Mode Current

During normal operation of the device, the currents (differential mode currents) on the phase and neutral lines are equal in magnitude and opposite in direction.

01 Symmetrical Winding

The two windings of the common mode inductor are symmetrically wound in opposite directions on the same core.

02 Opposite Magnetic Fields

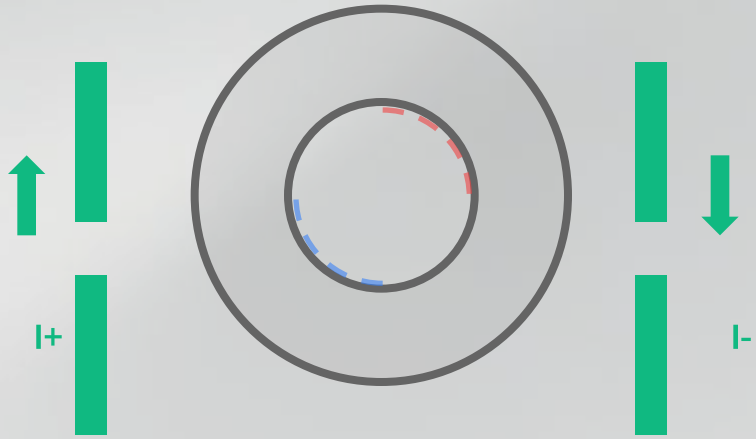
When differential mode current flows through the two windings, magnetic fields of equal magnitude and opposite direction are generated respectively.

03 Magnetic Flux Cancellation

These two opposing magnetic fields cancel each other out inside the core, resulting in zero total magnetic flux.

04 Low-Impedance Conduction

Since the core is not magnetized, the inductor presents extremely low inductive reactance to the differential mode current, equivalent to a short circuit, so the normal operating current can pass through unimpeded.



Schematic: Opposing magnetic fields cancel each other out, keeping the core in a 'zero flux' state.

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3. Principle 2: High-Impedance Suppression for Common Mode Noise

When common mode interference is present, noise currents appear simultaneously on both the phase and neutral lines and are in the same direction.

01 In-Phase Interference

Common mode noise currents flow in the same direction on both lines.

02 Same Direction Magnetic Fields

When these same-direction currents flow through the two windings, the generated magnetic fields are also in the same direction.

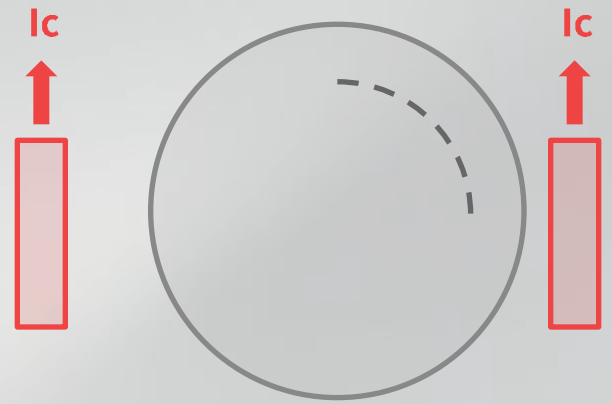
03 Magnetic Flux Superposition

The two same-direction magnetic fields superpose each other inside the core, causing the core to be strongly magnetized.

04 High-Impedance Suppression

The magnetized core exhibits extremely high magnetic permeability, causing the inductor to exhibit a huge common mode inductive reactance, which strongly hinders the common mode noise current and achieves the filtering effect.

Schematic of Common Mode Suppression Principle



Magnetic Field Superposition and Enhancement

In-phase currents generate a superposed magnetic field, and the core's high permeability creates a huge impedance to block common mode noise.

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4. Conclusion: Differential Mode Magnetic Cancellation, Common Mode Magnetic Superposition

Differential Mode Current: Magnetic field cancellation, lossless conduction

The magnetic fields generated by the differential mode current are opposite and cancel each other out. The core is almost not magnetized, presenting extremely low impedance, allowing useful differential mode signals to pass through without loss and ensuring the normal transmission of the circuit.

Common Mode Current: Magnetic field superposition, high-efficiency filtering

The magnetic fields generated by the common mode current are in the same direction and superpose each other. The core is fully magnetized and presents extremely high impedance, forming a strong suppression on the common mode interference signal, thus achieving a high-efficiency electromagnetic interference filtering effect.

Core Value: This ingenious design based on the principle of electromagnetic induction is the key to solving electromagnetic compatibility (EMC) problems. Parameters such as magnetic permeability and saturation flux density of the magnetic core directly determine its performance upper limit, making it an indispensable core component in the anti-interference design of power supply and signal lines.