Thin, light, and efficient.

Multilayer Power Inductors

MLP2012-V series

For high efficiency power management of mobile equipment

While the operating voltages of ICs are becoming increasingly lower with miniaturization in semiconductor process rules, the current consumption of cellular phones and other mobile equipment is growing larger, due to an increase of multifunctional equipment. In order to respond this “age of low voltages and high currents,” which began around 2000, and to extend battery life, the existing Series regulators for power supplies has been replaced by highly efficient, small DC-DC converters. The efficiency of DC-DC converters is largely affected by the core characteristics of power inductors. TDK has realized outstanding DC superposition characteristics that are comparable to those of wound inductors in multilayer inductors by adopting low-loss ferrite materials. The newly-developed MLP2012-V multilayer power inductor series exhibits up to 6% higher power conversion efficiency (according to study by TDK), compared to that of existing products (the MLP2012-S series). This series is optimal for small DC-DC converters of cellular phones, smartphones, game consoles and other mobile equipment.
In recent years, power supply methods for electronic equipment have been shifting from a traditional concentrated supply method to a POL (point of load) method, in which small power supplies are distributed in close proximity to ICs. For example, circuits in cellular phones or smartphones consist of blocks including transmission parts, signal processing parts/application parts, display parts, and the operating voltage for the ICs of each part differ. In addition, voltage ranges in which ICs can operate without malfunctioning are becoming narrower as operating voltages of ICs decrease, and effects such as drops in voltage due to wiring cannot be avoided when the concentrated supply method is used; for this reason, the POL method has been introduced, which locates small power supplies in close proximity to ICs. In cellular phones or smartphones that require detailed power management, the number of POL power supply channels can be as many as 20 to 30.

Traditionally, three-terminal regulators have been used as small power supplies for mobile equipment. A three-terminal regulator is an easy-to-use linear series regulator. Though it has an advantage of having a simple circuit and low noise, it also has a disadvantage of having low power conversion efficiency due to its principle. For this reason, in mobile equipment, which is becoming more and more current-consuming, DC-DC converters with better power conversion efficiencies have begun to replace three-terminal regulators in order to extend battery life.

A DC-DC converter is a power supply in which currents that are broken up into pulses by high-speed switching of a semiconductor device are converted into voltage by a transformer. Although it has a complex circuit, it is highly effective, with a power conversion efficiency of 80 to 90%.

In a DC-DC converter, a coil is connected on the output side so as to obtain direct currents with little voltage fluctuation. This coil is called a power inductor, and it largely affects the efficiency of the DC-DC converter.

**Basic configuration and power management of a smartphone**

**Types of regulated DC power supplies and small power supplies used for mobile equipment**

- **Regulated DC power supply**
  - Linear type
  - Switching type
- **Series regulator**
- **Shunt regulator**
- **DC-DC converter**

- **3-terminal regulator, LDO (low drop out)**
  - Advantage: Simple circuit, low noise, inexpensive.
  - Disadvantage: Low efficiency. A heat sink for cooling may be required.

- **DC-DC converter**
  - Advantage: Small and highly efficient. Requires no heat sink.
  - Disadvantage: Relatively complex circuit. Requires noise suppression measures.
Inductors are a main passive component, and they can be largely divided into wound inductors, in which conductive wire is wound around a core made of ferrite or other materials, multilayer inductors, in which a coil is sterically formed using multilayer stacking technology, and thin-film inductors, in which a coil is formed using thin film process technology. Generally, wound power inductors have been used for DC-DC converters. A lower number of turns is required by using a thick copper wire, making it possible to accommodate low resistance/high current applications.

In addition, recently, in small on-board DC-DC converters, power ICs integrating control ICs or MOSFETs (Metal-Oxide-Semiconductor Field-Effect Transistors) have been adopted. Due to the advancement of high-density integration, power ICs have become as small as several millimeters square, and as thin as approximately 1 mm. However, with wound power inductors, there are limitations on the formation and processing of drum cores and these cannot respond to size and height reduction of power ICs.

This problem can be solved by multilayer power inductors. Multilayer inductors are manufactured using ferrite sheets (dielectric ceramics for high-frequency use) on which coil patterns are printed with metallic paste. By arranging these sheets in multiple layers, a stereoscopic core is formed internally. This is a technology that was developed by TDK in 1980 for the development of SMD (surface mount device) inductors. At first, the technology was commercialized as inductors for low-frequency signal processing. Later, the product lineup was expanded to include inductors for high-frequency circuits, decoupling and other applications, through advancement of material technologies or stacking technologies. Multilayer inductors have smaller inductance compared to that of wound inductors, and for this reason, they are not suitable for large capacity DC-DC converters. However, because size and height reduction is easier to achieve compared to wound inductors, their demand for use in small-capacity DC-DC converters, such as those for mobile equipment, is rapidly increasing.
There are various types of multilayer chip inductors, and each is required to have characteristics suitable for their applications. For those for high-frequency applications, high Q characteristics or SRF (self resonant frequency) are important factors. On the other hand, multilayer power inductors for power supply applications, especially those for DC-DC converters, are required to have low resistance and high DC superposition characteristics, so as to reduce losses.

A factor that largely affects DC superposition characteristics is the material quality of the ferrite used for the core. In the process in which ferrite or other magnetic materials are magnetized by an external magnetic field, the ratio of the magnetic flux density of the magnetic material to the external magnetic field strength is called magnetic permeability. However, the magnetic permeability of a magnetic material is not uniform; as the external magnetic field strength becomes stronger, permeability gradually becomes smaller, as does the coil inductance.

In power inductors for DC-DC converters, it is desired that the value of DC-bias currents at which inductance reduction begins be as high as possible, as an alternating current is superimposed on the DC bias current.

The new MLP2012-V multilayer power inductor series developed by TDK offers a significantly higher rated current by improving DC superposition characteristics, through means such as the use of a low-loss ferrite material. Compared with the existing product (the MLP2012-S series), the series exhibits a maximum of 6% higher power conversion efficiency (according to a study conducted by TDK), in addition to achieving a low-profile structure with a height of 0.85 mm, through the application of an advanced stacking technology.

The MLP2012-V series consists of power inductors ideal for use in on-board DC-DC converters, which are becoming smaller and more low-profile. It also contributes greatly to the extension of battery life of mobile equipment that is subject to long-term continuous use and heavy load, including cellular phones, smartphones, digital cameras and game consoles.
Main features

1. Exhibits a maximum of 6% higher power supply circuit efficiency (according to a study by TDK), owing to the use of a low-loss ferrite material, etc.
2. Accommodates a broad range of applications with an increased rated current, due to the improvement of DC superposition characteristics.

Main applications

Power applications for power supply circuits of various mobile equipment, including smartphones, cellular phones, digital cameras and game consoles.

Main specifications and electrical characteristics

- **Dimension**: $2.0 \times 1.25 \times 0.85$ mm

<table>
<thead>
<tr>
<th>Part No.</th>
<th>Inductance [$\mu$H]</th>
<th>DC resistance [Ω]</th>
<th>Rated current [mA]</th>
</tr>
</thead>
<tbody>
<tr>
<td>MLP2012VR47M</td>
<td>0.47</td>
<td>0.11</td>
<td>1100</td>
</tr>
<tr>
<td>MLP2012V1R0M</td>
<td>1.0</td>
<td>0.20</td>
<td>900</td>
</tr>
</tbody>
</table>

![Inductance-frequency characteristics](image1.png)

![Inductance-DC superposition characteristics](image2.png)

Exhibits a maximum of 6% higher power supply circuit efficiency (according to a study by TDK), owing to the use of a low-loss ferrite material, etc.