Large-Current Choke Coils Formed by One-Piece Construction

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Abstract

The trend toward increasing the density of components mounted in a variety of electronic equipment has increased the demand for large-current compatible choke coils more than ever. This paper introduces the MPC and the MPLC Series of choke coils that have been developed to meet this demand using magnetic metallic materials and integrated one-piece constructions. These choke coils are optimized for use in the DC/DC converters that drive the CPUs of PCs, and the use of magnetic metallic materials with a one-piece construction achieve excellent characteristics in terms of low loss, DC superposition, electromagnetic noise and power load efficiency characteristics. The choke coil production lines will be expanded further in the future by decreasing the size, increasing component density and improving their efficiency.

Keywords

choke coil, one-piece construction, DC/DC converter, wire coil, magnetic metallic material

1. Introduction

The performance and increased number of functions offered by electronic equipment has recently been improving rapidly. As the need to reduce the size and weight of devices has also been increasing more than ever, the trend toward increasing the density of the mounted components is also tending to accelerate.

When we consider the field of the PC, for example, we notice that the percentage of notebooks among all shipped models is increasing. This is because of improvements in the performances of notebooks compared to desktop PCs as well as the popularity of the compactness of the notebook PCs, which are convenient both for carrying and storage. In particular, high-performance, multi-function models featuring high-resolution LCD displays, AV functions with DVD playback and video editing capabilities, and a wireless LAN function are becoming very popular among the notebook PCs.

As improvements in performance and functionality have increased the power consumption of the PCs, the decrease in the voltage requirement of electronic components such as CPUs has advanced. Thus overall, the increase in the power consumption is held down while the availability of functions improves. However, if it is assumed that the power consumption of a PC is unchanged, a decrease in the drive voltage will result in an increase in the required current level.

The choke coil is the component used in the DC/DC converter of a PC. As the voltage used by the PC decreases and the current used by it increases, the choke coil design is being influenced by requirements for large current compatibility, compact size, low loss and low noise.

This paper describes two series of high-power density power choke coils. These are the MPC Series featuring the large current compatibility optimized for use in CPU-drive DC/DC converters of PCs as described above, and the MPLC Series featuring the high inductance optimized for use for power line systems other than PCs.

2. Core Material

In order to deal with larger current loads, the core material of the choke coils has been changed from the previous ferrite to a metallic material. This has made it possible to achieve a high saturation flux density and to accommodate a larger current than before.

Nevertheless, metallic materials conduct currents and the eddy currents that may be produced when an AC voltage is applied might result in significant losses. Therefore, for the newly adopted magnetic metallic materials, we have provided insulation treatment for those materials that have low core loss and high saturation characteristics in order to implement choke coils that feature high saturation at the same time as low core loss characteristics.

3. Product Construction

3.1 MPC Series

The MPC Series are choke coils formed by a one-piece construction method that are made by pressurizing a coil obtained by winding a flat rectangular wire edgewise with a specially developed magnetic metallic material (**Fig. 1**, **Table 1** and **Table 2**).

We used a Fe alloy with a high saturation flux density and low core loss characteristics as the magnetic material, and ensure inductance by means of pressure forming.

To reduce the copper loss of the coil, we have adopted a flat rectangular copper wire that is advantageous for improving the coil space factor in a limited space. This wire is wound edgewise in order to reduce the winding height. The lead wires are then soldered, led out of the two opposite sides and one-piece pressure forming is applied in order to use the formed leads directly as the terminals. This process has eliminated the connection loss that would usually be produced by connecting the terminals to the wires and has made the choke coils compatible with a larger current than hitherto.

3.2 MPLC Series

The MPLC Series are choke coils with a one-piece construction that are formed by pressurizing a coil obtained by winding a round wire with a magnetic metallic material that has been newly developed for use in high-inductance applications (**Fig. 2**, **Table 3** and **Table 4**).

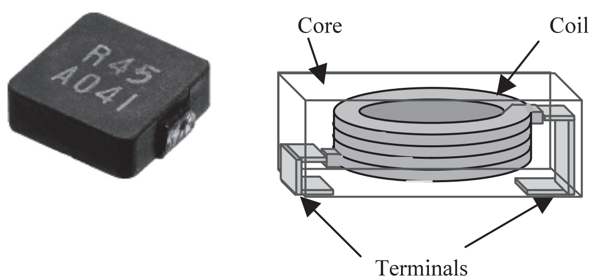

Fig. 1 External view and structure of MPC Series.

Table 1 Construction of MPC Series.

	MPC series
Coil	Flat Copper Wire
Core	Fe-based Metal Powder
Molding	Pressurization Molding
Terminal	Direct Terminals

Table 2 Dimensions and electrical characteristics of MPC Series.

Name	Dimensions[mm]	L[μH] @100kHz	Rdc [mΩ]	Rated Current [A]
MPC0750LR60	7.0max×8.0max×H5.0max	0.60±20%	2.30±15%	17.0
MPC1040LR36	10.3max×11.5max×H4.0max	0.36±20%	1.05±10%	25.5
MPC1040LR45		0.45±20%	1.10±10%	25.0
MPC1040LR56		0.56±20%	1.30±10%	23.0
MPC1040LR88		0.88±20%	2.30±10%	17.0
MPC1055LR36	10.3max×11.7max×H5.5max	0.36±20%	0.75±10%	32.0
MPC1055L1R0		1.00±20%	2.30±10%	18.5
MPC1250LR36	12.8max×14.5max×H5.0max	0.36±20%	0.65±10%	38.0
MPC1250LR50		0.50±20%	0.80±10%	35.0

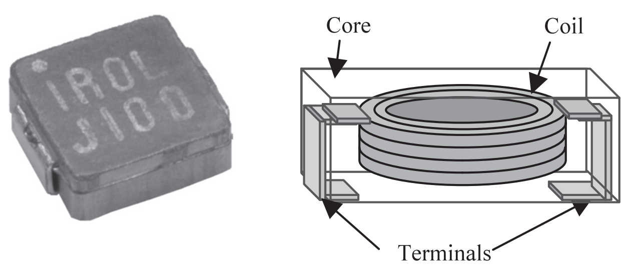

Fig. 2 External view and structure of MPLC Series.

Table 3 Construction of MPLC Series.

	MPLC series
Coil	Round Copper Wire
Core	Fe-based Metal Powder
Molding	Pressurization Molding
Terminal	Copper Frame

Table 4 Dimensions and electrical characteristics of MPLC Series.

Name	Dimensions[mm]	L[μH] @100kHz	Rdc [mΩ]max	Rated Current [A]
MPLC0730L1R0	6.9max×7.7max×H3.0max	1.0±20%	9.0	10.6
MPLC0730L1R5		1.5±20%	15.0	8.6
MPLC0730L2R2		2.2±20%	19.0	7.3
MPLC0730L3R3		3.3±20%	30.0	5.7
MPLC0730L4R7		4.7±20%	41.0	5.0
MPLC1040L1R0	10.2max×11.5max×H4.0max	1.0±20%	5.5	14.3
MPLC1040L1R5		1.5±20%	7.0	12.4
MPLC1040L2R2		2.2±20%	10.0	10.5
MPLC1040L3R3		3.3±20%	14.0	8.8
MPLC1040L4R7		4.7±20%	19.0	8.0

We used a Fe alloy with high magnetic permeability and saturation flux density characteristics as the magnetic material and have ensured a high inductance by means of one-piece forming by pressurization.

We adopted a round wire that is advantageous for varying the number of windings to deal with the high inductance, and a Cu alloy with high electrical conductivity to reduce the copper loss in mounting the terminals.

Both the MPC Series and MPLC Series are formed as a one-piece construction using wire coils and magnetic metallic materials independently developed for the respective choke coils in order to achieve compact sizes, high power densities and low losses. They also offer low leak magnetic flux and low electromagnetic noise, characteristics that are unavailable with traditional choke coils. These characteristics result from the use of a one-piece construction without clearance between the wire coil and the core and the gapless construction of the pressurized forming of the magnetic metallic material.

4. Product Characteristics

4.1 Product Lines

The MPC Series of compact choke coils are compatible with inductances from 0.36 to 1.0μH and currents from 17.0 to 38.0A and the product lineup consists of a □7mm × H5.0mm max. model, □10mm × H4.0 and 5.5mm max. models, and □12mm × H5.0mm max. models (Table 2).

The MPLC Series of compact choke coils are compatible with inductances from 1.0 to 4.7μH and currents from 5.0 to 14.3A, and the product lineup consists of □7mm × H3.0mm max. models and □10mm × H4.0mm max. models (Table 4).

4.2 DC-Superposed Characteristic

Thanks to the utilization of the high saturation flux density of the magnetic metallic materials, these choke coils achieve an excellent DC-superposed characteristic with little decrease in inductance under large current loads (**Fig. 3**). As a result, even when rush currents or excess current flows affect the power line the inductance will not degrade suddenly. This feature makes these products optimum as low-voltage, large-current choke coils for the multi-phase drives of the CPUs of notebook PCs.

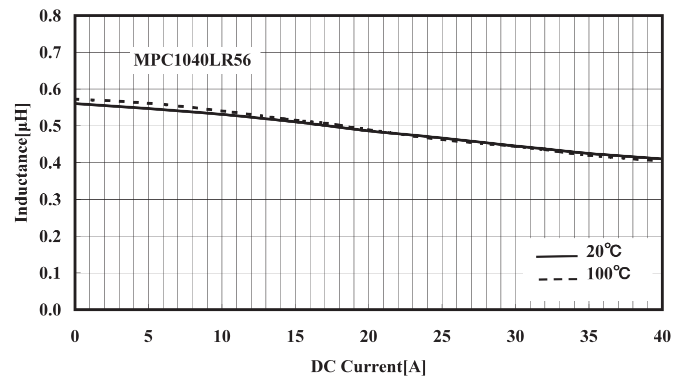

Fig. 3 DC-superposed characteristic.

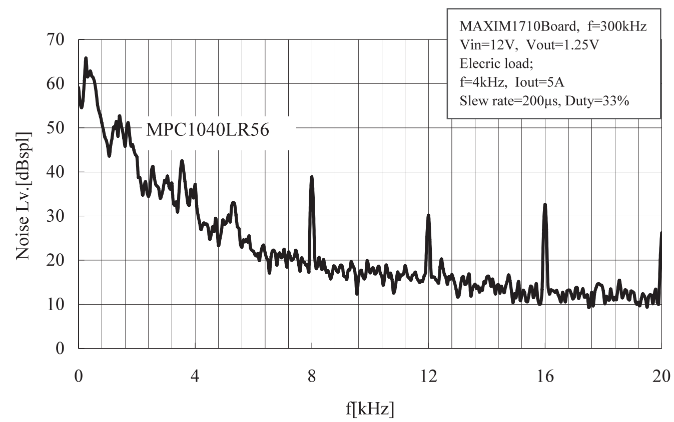

Fig. 4 Electromagnetic noise characteristic.

4.3 Electromagnetic Noise Characteristic

Traditional choke coils have been constructed by incorporating a pair of cores in the coil winding and therefore these coils had spaces between the cores and between each core and the coil winding. These gaps were usually fixed using adhesives etc. to stabilize the product and prevent it from rattling.

The present choke coils do not have gaps between the magnetic body and the coil winding because they are fabricated by one-piece pressure forming of the magnetic metallic material and coil winding. As a result, they feature low magnetic noise characteristics with a noise level of below 40dBspl even at the resonant frequency of the power load (**Fig. 4**). This makes these choke coils optimum for use in products with a high quietness requirement such as the CPU driver of notebook PCs.

4.4 Power Load Efficiency Characteristic

The magnetic metallic materials feature low core loss

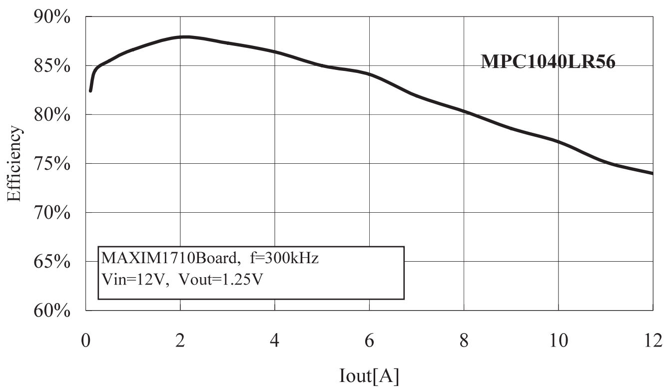

Fig. 5 Power load efficiency characteristic.

characteristics. In general, the core loss is dependent on the efficiency of the materials at low currents while the copper loss is dependent on that at high currents. These choke coils can achieve a high efficiency from low through high current loads. This is due to the use of magnetic metallic materials with low core loss characteristics and product designs that consider improvements of the wire coil space factor (**Fig. 5**).

4.5 Other Characteristics

The MPC and MPLC Series choke coils also present low leak flux characteristics thanks to the closed magnetic path structure made possible by one-piece pressure forming of the wire coil and the magnetic metallic material. They will not cause inductive coupling with other electronic components even when they are packaged in high densities, thereby making it possible to reduce concerns about the choke coil layout and considerations regarding other components at the circuit board design stage.

5. Conclusion

The MPC and MPLC Series are compact choke coils with a large current compatibility and feature electrical characteristics that are optimized for use in DC/DC converters with the associated large current increase/decrease voltages that are required for power supply lines. The features including large current compatibility and low electromagnetic noise characteristics of these choke coils make them suitable for the DC/DC converters that drive the CPUs of notebook PCs and other system power lines (GPUs, etc.), and their applications are actually expanding in these fields.

In the future, we will expand the specifications and product lines further as well as introducing product variations by positioning them as proposal-type products that are applicable for various applications. Such products will be able to deal with current trends in the electronics equipment industry, including multiplication of functions, improvements in power saving capabilities, size reductions, density increases and the need for higher efficiencies.

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