Multilayer Inductor Resolves Power Management Issues

High-frequency switching of DC/DC converter with low noise reduces the number of external components required of small and multifunctional mobile devices.

The diversification of the operating voltage of power supply circuits in mobile devices resulted from the multifunctionality of today's mobile devices. As a representative model of mobile devices, mobile phones equipped with camera, radio and television functions have nearly become standard on top of their communication functions. In order to operate these capabilities, a number of dissimilar voltages are needed. To do so, power supply circuits to convert voltages supplied by batteries into operating voltages needed by respective circuits are required and switching regulators, generally called DC/DC converters, are applied in many cases.

Meanwhile, as mobile devices become increasingly multifunctional, they are increasingly being called to become smaller and thinner as well. To meet this requirement, it is necessary either to cut down the number of components used or to downsize them. To address this concern, the number of inductors and capacitors required as external components can be reduced by using high frequency for the switching of DC/DC converters, thereby downsizing components. In terms of the switching frequencies, a 3MHz power management IC to control necessary power sources in a centralized manner has become predominant compared with the traditionally common 1MHz being used. With respect to the DC/DC converter IC to be applied to dispersed power sources, the 3 to 4MHz model is presently becoming mainstream. Under these circumstances, as one of the key components, power inductors with low inductance between 1.0 and 2.2μH are being called for. At the same time, as switching frequencies become higher, countermeasures against noises are also needed. To cope with all these issues, the inductor industry is promoting efforts to develop power inductors.

Table 1: Main characteristics of the LQM2HP and LQM2MP Series

Part No.	Inductance (μH)	Inductance measurement frequency (MHz)	Rated current (mA)	DC resistance (Ω)
LQM2HPNR47MG0	0.47±20%	1	1800	0.040 ±25%
LQM2HPN1R0MG0	1.0±20%		1600	0.055 ±25%
LQM2HPN1R5MG0	1.5±20%		1500	0.07 ±25%
LQM2HPN2R2MG0	2.2±20%		1300	0.08 ±25%
LQM2HPN3R3MG0	2.3±20%		1200	0.10 ±25%
LQM2HPN4R7MG0	4.7±20%		1100	0.11 ±25%

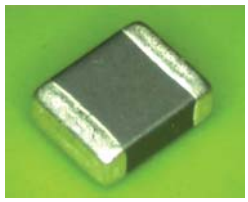
Part No.	Inductance (μH)	Inductance measurement frequency (MHz)	Rated current (mA)	Direct resistance (Ω)
LQM2MPNR47MG0	0.47±30%	1	1600	0.060 ±25%
LQM2MPN1R0MG0	1.0±30%		1400	0.85 ±25%
LQM2MPN1R5MG0	1.5±30%		1200	0.11 ±25%
LQM2MPN2R2MG0	2±30%		1200	0.11 ±25%

What is Expected of Power Inductors?

Primarily, power inductors required by power supply circuits of multifunctional and small mobile phones must be small in size and low in height. These products must exhibit performance that is commensurate with the high power conversion efficiency of power supply circuits. Power supply circuits must also exhibit resistance to noise in the power supply state.

A more detailed discussion of the performance requirements of this component is explained based on the power inductors developed by Murata Manufacturing Co., Ltd.

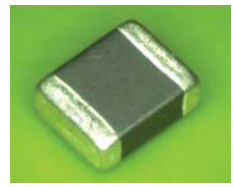
External appearance



2.5 × 2.0 × 0.9mm (1.0mm max.)

Fig. 1-1: LQM2HP multilayer power inductor from Murata Manufacturing

External appearance



2.0 × 1.6 × 0.9mm (1.0mm max.)

Fig. 1-2: LQM2MP multilayer power inductor from Murata Manufacturing

Multilayer Power Inductors

Small-sized, low-profile

Murata Manufacturing developed and began mass-producing the LQM2HP (2520 size) and LQM2MP (2016 size) multilayer power inductor series to meet the needs for downsizing power supply circuits. These inductors are designed to be low in height to fit the 1.0mm package height of the latest power management IC or the baseband IC to which the power is supplied. The external appearance of these multilayer power inductors are shown in Fig. 1.

These inductors feature good current superposition inductance characteristics. The current superposition inductance characteristics can be described as the nature of inductance values' lowering as electric

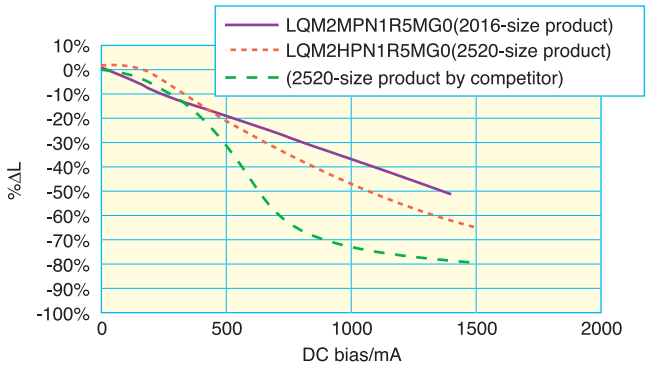


Fig. 2: Current superposition inductance characteristics of the LQM2HP and LQM2MP Series

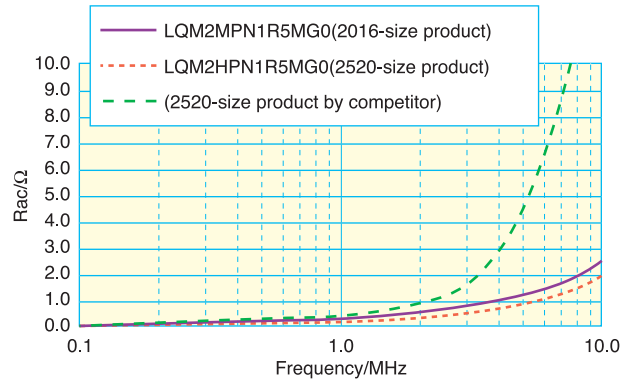


Fig. 4: Rac characteristics of the LQM Series

current increases while current is being applied to an inductor. This can be attributed to the saturation of magnetic flux due to the closed magnetic circuit structure of a multilayer inductor. In order to overcome this downside, Murata Manufacturing came up with a technology to control magnetic flux distribution in multilayer ferrite to reduce magnetic flux saturation, thereby improving current superposition characteristics, and eventually applied the technology to these products.

Table 1 shows the main characteristics of each product series and Fig. 2 shows their current superposition inductance characteristics.

Adapts to high power conversion efficiency

There is a correlation between the power conversion efficiency performance of a DC/DC converter and a power inductor as shown in Fig. 3. Power conversion efficiency in the pulse frequency modulation (PFM) mode, that is, the low-current loading state corresponding to the standby mode of mobile phones, has to do with inductors' alternating-current resistance (Rac) and current superposition inductance characteristics. Figure 4 shows each inductor's Rac characteristics and Fig. 5 shows the power conversion efficiency characteristics in the case of a DC/DC converter IC with a switching frequency of 4MHz. As the Rac characteristics in Fig. 4 show, the Rac is held low for the LQM Series. Moreover, as the current superposition inductance characteristics in Fig. 2 show, high-level inductance is ensured while current is being applied, representing favorable power conversion efficiency characteristics. This feature realizes high power conversion efficiency during the standby mode of a mobile phone, thereby contributing to extending the battery life.

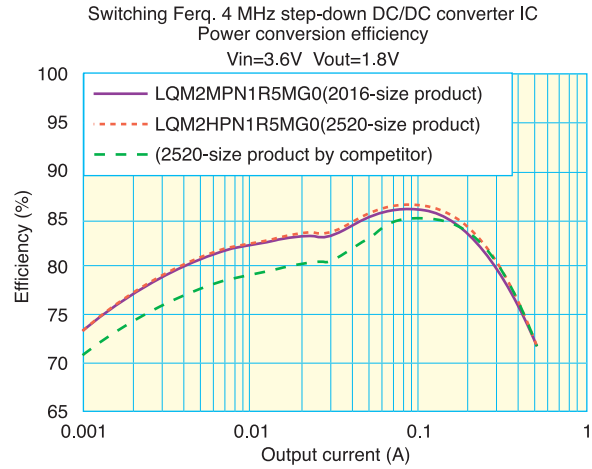


Fig. 5: Power conversion efficiency data

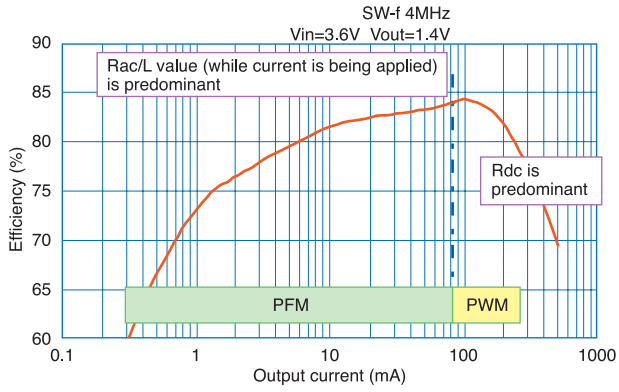


Fig. 3: Correlation between power conversion efficiency and inductor performance

Meanwhile, in the pulse width modulation (PWM) mode, which is the high-current loading state corresponding to the talk mode, direct-current resistance (Rdc) of inductors gets involved, and the LQM Series, featuring low Rdc characteristics indicates favorable power conversion efficiency in this case.

Adapts to noise-resistant performance

Applying a DC/DC converter to a power supply circuit of a mobile phone may have an adverse effect on the circuit as leakage flux from the inductor in-use triggers unstable operation of the power supply circuit. This problem can be addressed by using a multilayer inductor that has low leakage flux characteristics. The application of the multilayer inductor curbs noise induction to stabilize the power supply circuit. In addition, as leakage flux is low, the electromagnetic coupling with the signal lines and the others around the power supply circuit weakens to prevent signal purity from deteriorating due to noise induction.

Figure 6 shows the measurement data of leakage flux of wire wound inductors and multilayer inductors. Compared with wire wound inductors, which had traditionally been predominant among DC/DC converters, the leakage flux from the mul-

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tilayer counterparts is little. The characteristics of multilayer inductors whose leakage flux is little because of their closed magnetic circuit structure can be identified. From these data, it can be assumed that if a micro multilayer power inductor is used for a small high-speed switching DC/DC converter IC, its noise-resistance characteristics can also be demonstrated.

In Conclusion

As the needs for downsizing and thinning mobile equipment grow, components to be applied to them are required to become more and more miniaturized. By using high switching frequencies and by miniaturizing peripheral components, the need for downsizing and thinning DC/DC converters, which serve as power supply circuits, is being met.

Murata Manufacturing tried to develop small-sized multilayer power inductors, which is one of the key components of the DC/DC converters. As a result, the company came up with 2520- and 2016-size multilayer power inductors, which excel in current superposition inductance characteristics and leak little flux in the talk mode. The company will promote efforts to develop even smaller 2012- and 1608-size multilayer power inductors in a bid to contribute to designing high-performance, small-sized power supply circuits for mobile equipment application in the future.

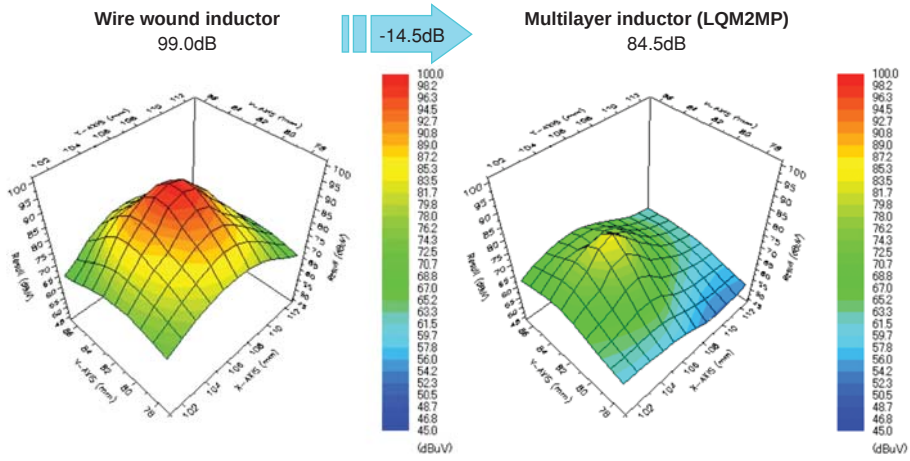

Fig. 6: Comparison data of the leakage flux between multilayer and wire wound inductors

About This Article:

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Please note the specification tables are to be corrected as follows.

Table 1: Main characteristics of the LQM2HP and LQM2MP Series

◆Inductance (μH)

Part Number	Error	Correction
LQM2MPN2R2MG0	2±30%	2.2±30%

◆DC resistance (Ω)

Part Number	Error	Correction
LQM2MPN1R0MG0	0.85±25%	0.085±25%