High-current EMI Suppression Chips

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Ferrites have evolved to meet the needs of today's designers.

FERRITES BEADS TO SURFACE-MOUNT DEVICES

When ferrites were first applied to circuits to suppress RF interference, it was generally done by stringing one or more small sleeves on a wire or slipping the same type of component over a pin. In most cases this worked relatively well, because the user had sufficient room to add beads if more attenuation was necessary. Also, since the device was hand-wired the added effort was not too costly. At that time, there was no regulatory body which closely monitored the emission of electromagnetic energy. The beads were primarily to ensure functionality of the device itself, and there were few applications involving the suppression of interference currents over 500 mA.

Today, the designer lives in a different world. The regulatory considerations are such that a much larger emphasis must be placed on EMI suppression for immunity as well as emission. Circuitry is built on boards which are assembled with tape and reel components at mind-boggling speeds. Except for applications where the ferrite tube is slipped over a cable, generally outside the enclosure, there is literally no room inside for a ferrite bead to fit. Moreover, a cylindrical shape does not lend itself to stable positioning on the board.

Very small flat shapes (chips) have taken the place of the venerable bead. These chips are available in standard EIA sizes and provide impedance of up to 2000 ohms at frequencies in the interference band. They are easy to employ in taped and reeled containers. Moreover, they are very cost-effective and are available in a wide variety of shapes and sizes (Figure 1).

HIGH-CURRENT CHIPS

Many more areas of application for suppression must be addressed today. Among these are traces which carry currents of 3 A or greater. To handle these conditions, higher current chips must be used to provide the necessary attenuation over the interference band and must be robust enough to continuously handle the higher current levels. Fortunately, there are chips available to operate at 6 A with surges approximately 50% higher.

CHIP STRUCTURE

High-current chips as well as their lower current counterparts are fabricated by producing finely powdered nickel-zinc ferrite and combining it with organic binders and a carrier. The ferrite slurry is then cast into a film over which a conductive paste is screened in a pattern to form a trace. It is possible to laminate several layers of these into a stack wherein the circuits on each are connected with vias. Top and bottom layers of the ferrite film are applied and the component is subsequently provided terminations at each end with a conductive paste to complete the circuit path. It is then sintered, the ferrite and the conductor maturing at essentially the same temperature.

Another approach is to build up the component by alternately screening layers of ferrite and conductor slurries with drying steps between. The conductor is laid down in the trace to produce very nearly the same type of structure as previously described. Termination and co-firing follow, along with a subsequent nickel barrier and solder plate for the terminals.

Typically, for the high impedance, low-current types, the conductive traces are less than 0.015 mm in height and about 0.13 to 0.25 mm in width. The limited cross section is used to facilitate the development of multiple turns in a confined volume so that higher inductive reactance might be produced.

The primary difference in the chips which can handle larger currents lies in a significantly larger conductor cross section, the via construction, the trace pattern and the mass of ferrite volume surrounding the trace. Although high-current chips are available in all of the EIA series footprints, they differ from the lower current rated chips in that they are not available in the high impedance ranges.

Table 1 compares the commonly available high-current chips according to size, the impedance at 100 MHz and the maximum rated current. Figure 2 describes typical high-current chip impedance versus frequency data, while Figure 3 shows the effect of current levels on comparable high-impedance (low-current rated) as well as the high-current chips.

It should be noted that impedance is adversely affected by the higher cur-

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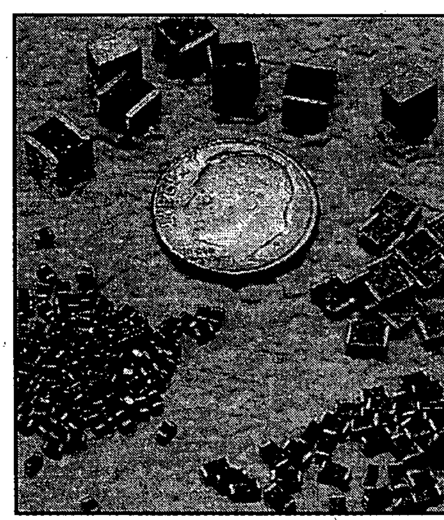

***Figure 1.** High-current EMI Suppression Chips.*

HIGH-CURRENT EMI SUPPRESSION CHIPS . . . *Continued from page 68*

EID Size	Impedance @ 100 MHz (No Load) ohms	Rated I max mA
0805	31	3000
1206	80	3000
1806	60	6000
1812	80	6000
2220	600	4000

Table 1. *Typical High-current Chip Performance.*

rent, particularly in the lower frequency regions (under 50 MHz). This is due to the fact that the ferrite's real permeability (μ') is high enough to contribute significantly to the total impedance in this frequency region:

$$Z = R + j\omega l$$

or

$$Z = K\omega\mu'' + jk\omega\mu'$$

As current increases the ferrite material surrounding the conductor approaches saturation and μ' becomes smaller.

Of further benefit, the thermal stability of the high current chip is considerably greater by virtue of its modified construction. With higher current levels it continues to run cool while the standard, lower current rated device deteriorates, producing lower effective impedance as soon as it becomes elevated in temperature. Both μ' and μ'' are depressed as the temperature rises.

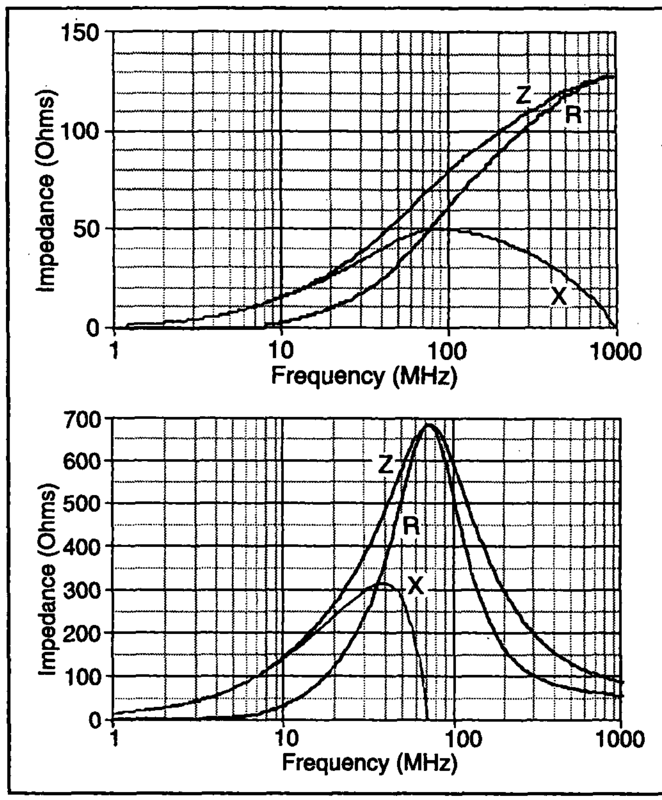

Figure 2. *Impedance vs. Frequency for Sample High-current Chips.*

TYPICAL APPLICATIONS

Obviously, most application areas for high current chips are in the power sections of digital devices. Some of these include:

- Trace between the power supply and the VCC
- Audio output circuits, keeping EMI off the output cable
- Power feed to the PC board on drives handling interference at high current surges
- DC power lines to various output devices, cleaning the AC off the line
- Filtering the DC power between boards, again insuring that it is free from AC interference

CONCLUSION

Advancements in the sophistication of ferrites and increasingly stringent requirements have changed the climate in which the designer works. The prospective user of high-current impedance chips is advised to contact the chip vendor to acquire additional information which might be appropriate for the application. Data relating to temperature-current-impedance relationships is available. So too are recommendations on reflow and cleaning operations.

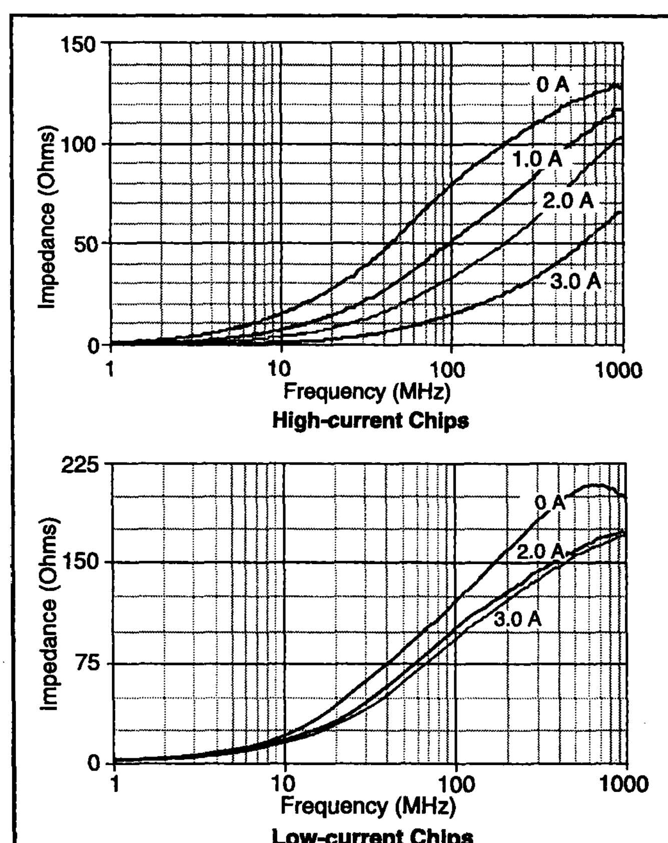

Figure 3. *Effect of Current Levels for Sample High-current and Low-current Chips.*

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