BY LEE HILL

All about surface-mount ferrites

Simple, two-terminal SMT (surface-mount-technology)-ferrite-bead components perform crucial functions in many systems. For example, one might suppress electromagnetic emissions from a power wire. Another might provide isolation between a digital circuit and a wireless transceiver. You may be surprised to learn that the performance of a ferrite bead in any power-filtering application can vary by more than a factor of 10, depending on the magnitude of dc current passing through the part during actual operation. Understanding that behavior under the influence of dc bias can help you create quieter designs and avoid drawing wrong conclusions when troubleshooting.

Manufacturers rate all ferrite beads according to a chart that shows impedance magnitude versus frequency (**Figure 1**). You normally use a ferrite bead in a series-connected noise-blocking configuration. For that application, you should select a ferrite bead with suitably low impedance at dc but high impedance at the frequencies you wish to suppress.

An example involves the 5V-dc supply voltage in a desktop electronic appliance. Assume that the 5V supply provides host power to an external USB port. You may worry that noise from inside the system due to an internal 100-MHz clock might find some low-impedance path backward through the 5V supply circuits, ultimately making its way onto an external power cable. If that situation happens, your system might fail radiated-emissions testing due to radiation from that cable. To attenuate the passage of that noise power, you place a ferrite bead in series with the output of the 5V supply.

What happens to the impedance of that ferrite bead, and hence its noise-suppressing ability, when you plug in an external, host-powered USB device? Suppose that, in a quiescent state, the filtered 5V power net draws only 100 mA. Connecting an external USB device causes the device to draw an additional 200 mA through the ferrite bead.

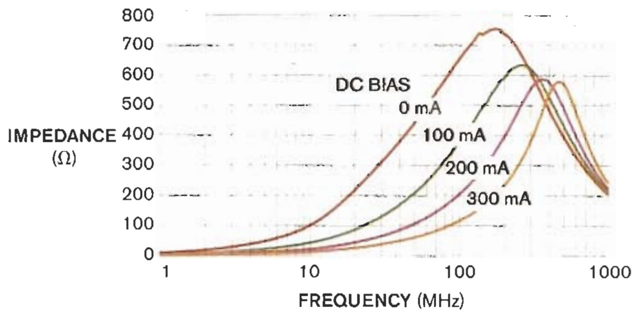

Figure 1 DC-bias current changes the performance of the ferrite bead.

Figure 1 plots a family of four curves for the ferrite bead. Each curve depicts the relation of impedance to frequency for some value of dc-bias current. An impedance bridge adds a dc bias to the device under test, generating these curves. According to the plots, changing the current from 100 mA before you plugged in the USB device to 300 mA after you plugged in the device decreases the impedance of the ferrite bead at 100 MHz from 400 to 120Ω. Assuming that the emitted radiation varies inversely with the impedance of the ferrite bead, you just increased the radiated emissions by more than 10 dB!

A casual observer might mistakenly conclude that the external USB device caused the increase in emissions. It did, indirectly, but only because the additional dc current draw modified the performance of the ferrite bead. An experienced EMI (electromagnetic-interference) troubleshooter would notice the contravening evidence that the external USB device doesn't even have a 100-MHz oscillator and the noise at 100 MHz was present before he attached the USB device.

In short, remember:

- Don't use a ferrite bead unless you have data showing impedance versus frequency while under the influence of dc-bias current.
- Don't operate ferrite beads close to their maximum rated current; impedance changes markedly as you approach the maximum rated current.
- In general, for any given level of bias current, a larger, 0805-sized ferrite bead exhibits better performance than a smaller, 0603-sized ferrite bead.

Ferrite beads can be tricky, but look on the bright side: You now have a cool little filter whose performance depends on bias current; change the bias and you can tune the filter for optimum noise suppression. EDN

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