Chip beads for high-frequency noise suppression in smartphones

Effective EMC solution with a single component

Smartphones must support more bands and operate at ever higher frequencies up to several GHz. For this purpose, TDK’s expanded series of MMZ multilayer chip beads enables effective noise suppression over a wide frequency range with a single miniaturized component.

Effective EMC design in today’s smartphones and tablets is especially challenging for design engineers. Not only do these devices pack antennas and radios for 2G, 3G, and 4G services into a compact geometry, they also offer an increasing number of extra features such as WLAN, Bluetooth, and GPS connectivity, still and video cameras, and high-resolution displays.

From an EMC standpoint, this means that higher frequency signals are being used, which extend into the GHz range and create harmonics. The result is a more complex EMC environment with higher levels of electromagnetic interference (EMI) or noise. Therefore, noise control in GHz bands has become a very important issue.

Because the Tx and Rx antennas are very close to each other, the EMI from the Tx and Rx signals of mobile communications can severely impact the performance of the smartphone. Even a low noise level can lead to a significant increase in the input power to the antenna, thus reducing the reception sensitivity. While this is usually not a problem in locations with high signal strength, reception may be impossible in locations where the Rx signal is weak.

The number of frequency bands supported in smartphones also creates its own design challenges. Since each frequency band requires noise control, the number of EMC components also increases, making it difficult to satisfy the need for smaller and slimmer mobile devices. In order to reduce the number of components needed and the space they fill, smartphone designers are looking for very compact EMC components that can cover a broad frequency range.

To meet the requirements of EMC in the next generation of mobile devices, TDK has expanded its lineup of multilayer Gigaspira® chip beads with three new types:

- MMZ-1005V, which offers the world’s highest impedance in the GHz band,
- MMZ-0603E, which is the miniaturized version of the existing MMZ-1005E
- MPZ-1005E, which offers low DC resistance, high current capability, and high impedance.

Moreover, thanks to the broad frequency range covered by the new Gigaspira chip beads, it is possible to implement effective noise control for several frequency bands with just one chip.
Basic principle of noise suppression by chip beads

A chip bead is a component that offers noise suppression when placed inline with those transmission lines that are likely to be sources of EMI emissions. Because they are so convenient, chip beads are broadly used for many different kinds of devices.

Impedance (Z), which is the main characteristic of chip beads, is the combined resistance of reactance (X) and resistance (R). The reactance components are dominant in the low frequency range and function as inductors that reflect noise. At higher frequencies, the resistance components increase and function as resistance that converts noise to heat and absorbs it. Figure 1 shows the typical frequency characteristics of chip beads.

Figure 1: Typical frequency characteristics of chip beads: The attenuation maximum is reached at a frequency where the reactance of the inductive component has dropped to 0. TDK Gigaspira chip beads are thus able to suppress noise over a wide frequency range.
Longitudinally wound internal conductor

Gigaspira chip beads have achieved higher impedance through TDK’s proprietary multilayer structure and ferrite technologies. Figure 2 shows the internal configuration of standard chip beads and that of the newest Gigaspira chip beads. In a standard chip bead, the coil component (L) of the internal conductor, and the stray capacitance (C) between the internal conductor and external electrode generates self-resonance (LC resonance), and the impedance decreases in the frequency range higher than the self-resonant frequency (SRF).

The coil of a Gigaspira chip bead is wound in the longitudinal direction of the product and perpendicular to the terminal plane. This results both in reduced stray capacitance and an increase of the SRF into the high frequency region.

Figure 2: Relationship of the internal configuration to the self-resonant frequency (SRF): In a standard bead, the winding direction of the coil is parallel to the plane of the terminal electrode (left), which results in a terminal electrode and stray capacitance in each internal conductor. By contrast, the winding of the TDK Gigaspira beads is perpendicular (right), enabling a significantly reduced stray capacitance for the terminal electrodes and increased self-resonant frequency (SRF).
A further advantage of the longitudinal winding is that it enables an increase in the number of coil windings and, thus, a higher impedance than standard chip beads (Figure 3). This extends impedance into the high frequency range and enables removal of noise components in such high frequency bands, where standard chip beads are ineffective. As a result, Gigaspira chip beads are highly effective EMC components in smartphones and other mobile devices that use a variety of communication frequency bands. The EMI level measurement results also confirm the excellent noise suppression effect of Gigaspira beads (Figure 4).

![Figure 3: Superior impedance and frequency characteristics of TDK Gigaspira chip beads: The reduced stray capacitance of the TDK Gigaspira beads enables them to suppress EMI in the high frequency range where standard beads are no longer effective.](image)

Noise suppression of TDK Gigaspira beads in comparison with standard chip beads

![Figure 4: Thanks to their special coil design, TDK Gigaspira beads feature significantly higher impedance values over a very broad frequency spectrum than standard chip beads.](image)

![Figure 5: As a result of their higher impedance values, Gigaspira beads offer much better noise suppression than standard components.](image)
Broad lineup of Gigaspira chip beads

TDK offers a lineup of chip beads with four types of Gigaspira beads (Table).

The first is the MMZ-V series, which features the world’s highest impedance in the GHz band. In particular, this type offers an especially high impedance in the range from 0.7 GHz to 3 GHz, and can thus suppress noise not removed by the existing MMZ-E series. As a result, the MMZ-V series offers excellent suppression of typical interference found at several GHz in LTE or WLAN, and of other high-frequency noise.

The MMZ1005-E type features a self-resonant frequency (SRF) that has been raised into the GHz range, which is (much) higher than that of standard chip beads. This enables one component to offer effective noise control over a wide frequency range. Like the MMZ-V series, its impedance is in the GHz range and thus also higher than that of standard types. The series offers 14 types based on 4 different materials to yield a broad range of frequency characteristics. The MMZ1005-E types are suited for noise suppression on general to high-speed signals.

The MMZ0603-E type offers impedance values equivalent to those of the 1005 size in a miniaturized EIA 0603 package (0.6 mm × 0.3 mm × 0.3 mm). This represents a 78 percent volume and 64 percent footprint reduction compared to the 1005 package. Thanks to its optimized internal configuration, the MMZ0603-E type features an SRF that is higher than that of the larger MMZ1005-E component. The series offers 8 types based on 3 different materials to yield a broad range of frequency characteristics. The MMZ1005-E types are suited for noise suppression on general to high-speed signals.

The fourth type of Gigaspira chip bead is the MPZ-E series. Owing to its low DC resistance compared to the MMZ-E series and high current capability, it is ideal for use in power lines or for ensuring low power consumption in signal lines. The impedance values of the MPZ-E series are higher than those of standard MPZ types. The series includes the S type with high impedance ratings across a wide frequency range extending up into the GHz range, and the F type with sharply increased impedance values in the GHz range.

Table: Key data for TDK Gigaspira chip beads

<table>
<thead>
<tr>
<th>Series</th>
<th>Impedance @ 100 MHz [Ω]*</th>
<th>Impedance @ 1 GHz [Ω]**</th>
<th>Impedance @ 2.5 GHz [Ω]**</th>
<th>DC resistance [Ω]</th>
<th>Rated current [mA]</th>
</tr>
</thead>
<tbody>
<tr>
<td>MMZ-V</td>
<td>75 to 180</td>
<td>500 to 1200</td>
<td>1400 to 3000</td>
<td>0.9 to 1.6</td>
<td>150 to 250</td>
</tr>
<tr>
<td>MMZ1005-E</td>
<td>47 to 2200</td>
<td>800 to 3000</td>
<td>--</td>
<td>0.65 to 2.2</td>
<td>150 to 300</td>
</tr>
<tr>
<td>MMZ0603-E</td>
<td>600 to 1000</td>
<td>1000 to 1800</td>
<td>--</td>
<td>1.6 to 2.6</td>
<td>125 to 150</td>
</tr>
<tr>
<td>MPZ-E</td>
<td>33 to 330</td>
<td>200 to 600</td>
<td>--</td>
<td>0.22 to 0.45</td>
<td>700 to 1500</td>
</tr>
</tbody>
</table>

* ±25 %
** ±40 %