Mini filters for multiband devices

Available space inside smartphones continues to shrink as they add more functions and serve more frequency bands. TDK has expanded its diplexer portfolio with the miniature DPX 1005 multilayer diplexer for WLAN and Bluetooth at 2.4 GHz and 5.0 GHz, which features power-saving low insertion losses with the smallest case size.

Multifeed antennas in smartphones are designed to serve multiple frequency bands for cellular and wireless services, including GPS, wireless LAN, Bluetooth, and more. While these shared broadband antennas minimize the number of antennas needed and thus help to save precious space in the smartphone, they require additional filtering in order to ensure good signal differentiation of the narrowly spaced frequency bands. A key component at the antenna interface is the diplexer, a passive component that combines a high-pass filter (HPF) and a low-pass filter (LPF).

When mounted at the antenna interface, diplexers have one shared port on the antenna side and two output ports on the RF frontend side. Their job is to separate compound Rx signals into their individual frequencies (high-band, low-band) and to combine separate Tx signals for transmission over the common antenna (Figure 1).

Block diagram of the WLAN/Bluetooth circuit in a smartphone

Figure 1:
The new diplexer of the TDK DPX series is used for separating and combining WLAN and Bluetooth signals in the 2.4-GHz and 5-GHz bands.
Proven LTCC technology

As ever more filters are needed to serve the growing number of frequency bands, one of the foremost design requirements for diplexers is miniaturization. TDK’s new DPX105950DT-6010B1 multilayer diplexer for WLAN and Bluetooth at 2.4 GHz and 5.0 GHz is manufactured using an advanced LTCC (low temperature co-fired ceramic) process and features a tiny footprint of just 1.0 mm × 0.5 mm and an ultra-flat insertion height of only 0.4 mm. It is thus the world’s smallest component of its kind and more than 60 percent smaller than existing 1608 types.

The new diplexers are realized with an LC design. In the LTCC process, which is proven in a variety of high-frequency components and modules besides the DPX series, the conductor patterns for multiple layers are screen printed on dielectric green sheets (alumina-based glass-ceramic). The electrodes and striplines thus created on the dielectric sheets are electrically connected by via holes to form a capacitor part and inductor part, which in turn function as the HPF and LPF, respectively, of the diplexer. After printing, the sheets are layered, cut and divided into elements, and then fired. Figure 2 shows the basic internal structure of a multilayer diplexer.
Basic internal structure of the TDK DPX 1005 multilayer diplexer

Figure 2:
Internal electrodes or striplines are formed by screen printing conductor paste (silver, etc.) onto dielectric green sheets. The sheets are stacked to form multiple layers, cut and divided into each element, and then fired at a temperature lower than the melting point of the silver conductor.

At approximately 900 °C (and even less) the LTCC firing temperature is below the melting point of silver (962 °C), which is used as a conductor. A special challenge in multilayer manufacturing is to produce ceramic devices with very precise dimensions without warping. This can occur when materials with different coefficients of thermal expansion (CTE) are used. Here, too, where the layers for the inductor and capacitor part of the new DPX 1005 diplexer employ different ceramic materials: The dielectric for the inductor part has a low dielectric constant, while that for the capacitor has a high dielectric constant. For this reason, TDK employs materials with a matching CTE to create high-precision multilayer components with no warping during firing.
Better power efficiency and selectivity

The high-band side supports 5-GHz wireless LAN (IEEE802.11a/n/ac), while the low-band side supports 2.4-GHz wireless LAN (IEEE802.11b/g/n) and Bluetooth. Thanks to the diplexer’s ultra-thin ceramic layers, it is not only smaller than conventional diplexers, but also features superior performance. With a maximum low-band and high-band insertion loss of just 0.5 dB and 0.8 dB, respectively, the new 1005 diplexer offers better power efficiency than existing diplexers (Figure 3), a factor that contributes to longer battery life. Moreover, the new diplexer’s minimum low-band and high-band attenuation of 23 dB and 25 dB, respectively, means that its selectivity is likewise improved.

Low-band and high-band insertion loss of the TDK DPX 1005 multilayer diplexer

Figure 3:
The new TDK DPX 1005 multilayer diplexer features better insertion loss than conventional diplexers, thus offering better power efficiency.
With the new TDK DPX 1005 multilayer diplexers, which began mass production in March 2014, TDK is addressing the unrelenting demand for further size and height reduction of components. The new component reduces the mounting area and volume needed in the RF transceiver circuits for wireless LAN and Bluetooth in smartphones and other mobile communication devices, thus contributing to the realization of smaller, thinner and lighter devices. The miniature diplexers are also well-suited for integration into modules.

Table: Key data for the TDK DPX 1005 multilayer diplexer

<table>
<thead>
<tr>
<th>Type</th>
<th>DPX105950DT-6010B1</th>
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<tbody>
<tr>
<td>Dimensions [mm]</td>
<td>1.0 × 0.5 × 0.4</td>
</tr>
<tr>
<td>Maximum low-band insertion loss @ 2.4 GHz to 2.5 GHz [dB]</td>
<td>0.5</td>
</tr>
<tr>
<td>Maximum high-band insertion loss @ 4.9 GHz to 5.95 GHz [dB]</td>
<td>0.8</td>
</tr>
<tr>
<td>Minimum low-band attenuation @ 4.8 GHz to 6.0 GHz [dB]</td>
<td>23</td>
</tr>
<tr>
<td>Minimum high-band attenuation @ 2.4 GHZ to 2.5 GH [dB]</td>
<td>25</td>
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