Solving Network Congestion with Carrier Aggregation

High-performance RF solutions from Qorvo® enable carrier aggregation
Carrier Aggregation Explained

Mobile network carriers and manufacturers are challenged with large data uploads and downloads. With the increase in video and social media content, the challenge has increased exponentially. Enter carrier aggregation (CA); a method used to address this challenge in the mobile ecosystem.

CA is a technique used to combine multiple LTE carrier signals to increase data rates and improve network performance. CA allows increased data rates and improved network performance in the uplink, downlink or both.

In the table below describing LTE category downlink bandwidths and data rates, any bandwidth above 20MHz requires at least 2 component carriers (CC), above 40MHz requires at least 3 CC and above 60MHz requires at least 4 CC.

Commercial LTE networks started with category 3 and 4 devices supporting 100 to 150Mbps with continuous 20MHz spectrum. As shown below, category 11/12 will bring 600Mbps during 2016, with expected rates of 1Gbps in the future.

<table>
<thead>
<tr>
<th>Aggregated DL BW</th>
<th>DL Data Rate</th>
<th>Modem Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>10MHz</td>
<td>75Mbps</td>
<td></td>
</tr>
<tr>
<td>15MHz</td>
<td>100Mbps</td>
<td>LTE Category 3</td>
</tr>
<tr>
<td>20MHz</td>
<td>150Mbps</td>
<td>LTE Category 4</td>
</tr>
<tr>
<td>25MHz</td>
<td>185Mbps</td>
<td></td>
</tr>
<tr>
<td>30MHz</td>
<td>225Mbps</td>
<td></td>
</tr>
<tr>
<td>40MHz</td>
<td>300Mbps</td>
<td>LTE Category 6/7</td>
</tr>
<tr>
<td>50MHz</td>
<td>375Mbps</td>
<td></td>
</tr>
<tr>
<td>60MHz</td>
<td>450Mbps</td>
<td>LTE Category 9/10</td>
</tr>
<tr>
<td>80MHz</td>
<td>600Mbps</td>
<td>LTE Category 11/12</td>
</tr>
</tbody>
</table>

- Above assumes 64QAM in the downlink
- The scaling in data rate between 64QAM and 256QAM is a factor of 1.33 (8 bit symbol versus 6 bit symbol)

CA Design Challenges and Qorvo’s Response

Device Power Consumption

CA increases device power consumption during large downloads. Large file download speeds increase at the cost of battery life. Qorvo addresses this challenge by providing filters and switches with low insertion loss and front-end modules with low current consumption and high linearity.

Isolation/Cross-Isolation/Attenuation in Multiplexer Filters

CA creates a higher probability of interferences. Multiband signals can interfere with each other due to insufficient filter attenuation. System desense can occur when isolation or cross-isolation between the Tx and Rx paths is insufficient, creating a scenario where the sensitivity of the receiver is degraded.

Qorvo’s LowDriftTM BAW technology is ideally suited to optimize isolation and attenuation performance across bands to help designers mitigate these challenges.

Insertion Loss & Isolation in Diversity and Antenna Switch Modules

Switches require ultra-high linearity and low insertion loss in a CA application. Any increase in insertion loss may result in an increase in system noise figure in the receiver path and reduces overall PA efficiency, reducing battery life and device signal range.

Mobile devices feature high-speed up/down links to provide video and data. Receiver sensitivity can be affected by noise, which can affect signal reception. This noise can cause system desense.

High switch isolation minimizes interference, leakage or desense from one port to the other. 2nd or 3rd harmonics can interfere with another frequency band due to insufficient isolation. In the figure to the right, B17’s uplink 3rd harmonic interferes with B4 downlink. High switch isolation is required to mitigate this situation.

Qorvo switch technology is optimized for low insertion loss, high isolation and high power handling capability. These attributes along with wideband frequency coverage and a large portfolio breadth make Qorvo the one stop shop for CA switch applications.

PA – Linearity in the Radio Environment

Two or more component carriers in uplink CA is a major challenge. Mobile device designers must reduce harmonics, as well as intermodulation and cross-modulation products to meet stringent wireless regulatory standards. Therefore, the PA configuration must be tuned for very high linearity, even in a backed-off state. The tradeoff of linearity comes at the expense of efficiency and battery life. These tradeoffs as well as adjacent channel leakage, spurious emissions, sensitivity, selectivity and intermodulation all must be considered.

Although discrete designs could provide some benefit, this approach comes at the expense of higher loss and longer development times. Using optimized Qorvo front-end module products like RF Flex™, RF Fusion™ and MMPA modules with best-in-class efficiency and linearity provides the performance and ease of use required for CA applications.
Qorvo’s Product Response

Qorvo’s continuous innovation of its core RF solutions such as filters, amplifiers, switches and antenna tuning devices enables our customers to meet new design requirements like CA.

### Multiplexer Solutions

<table>
<thead>
<tr>
<th>Bands</th>
<th>Part Number</th>
<th>Description</th>
<th>Size (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bands 39 and 41 Wideband</td>
<td>QM25001</td>
<td>Tx/Rx TDD Multiplexer</td>
<td>2.5x2.0</td>
</tr>
<tr>
<td>Bands 39 and 41 Narrow</td>
<td>QM25011</td>
<td>Tx/Rx TDD Multiplexer</td>
<td>1.7x1.3</td>
</tr>
<tr>
<td>Bands 39 and 41 Narrow</td>
<td>QM25012</td>
<td>DRx TDD Multiplexer</td>
<td>1.5x1.1</td>
</tr>
<tr>
<td>Band 1 and 3</td>
<td>QM25005</td>
<td>Tx/Rx FDD Multiplexer</td>
<td>3.0x2.0</td>
</tr>
</tbody>
</table>

### Diversity Rx Modules

<table>
<thead>
<tr>
<th>Function</th>
<th>Part Number</th>
<th>Description</th>
<th>Band Coverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>B25, B66, B3, B7, B39</td>
<td>QM63001A</td>
<td>Diversity Module with Diplexed B25+B66 to Enable CA</td>
<td>4.0x2.7</td>
</tr>
<tr>
<td>B1, B3, B25, B7, B39</td>
<td>QM63001</td>
<td>Diversity Module with Diplexed B1+B3 to Enable CA</td>
<td>4.0x2.7</td>
</tr>
</tbody>
</table>

### Switch Solutions

<table>
<thead>
<tr>
<th>Function</th>
<th>Part Number</th>
<th>Description</th>
<th>Band Coverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>SP4T + SP4T</td>
<td>RF1680</td>
<td>Diversity Rx Switch</td>
<td>Up to 3.8GHz</td>
</tr>
<tr>
<td>SP6T + SP6T</td>
<td>RF1681</td>
<td>Diversity Rx Switch</td>
<td>Up to 3.8GHz</td>
</tr>
<tr>
<td>SP9T + SP7T</td>
<td>RF1682</td>
<td>Diversity Rx Switch</td>
<td>Up to 3.8GHz</td>
</tr>
<tr>
<td>SP6T + SP6T</td>
<td>RF1683</td>
<td>Diversity Rx Switch with Integrated Diplexer</td>
<td>Up to 3.8GHz</td>
</tr>
<tr>
<td>SP7T + SP7T</td>
<td>RF1890A</td>
<td>Antenna Switch Module</td>
<td>Up to 2.7GHz</td>
</tr>
<tr>
<td>SP12T + SP9T</td>
<td>RF1891</td>
<td>Antenna Switch Module</td>
<td>Up to 2.7GHz</td>
</tr>
</tbody>
</table>

### Integrated RFFE Modules

<table>
<thead>
<tr>
<th>Function</th>
<th>Part Number</th>
<th>Description</th>
<th>Band Coverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>B7, B30, B38, B40, B41</td>
<td>QM75001</td>
<td>RF Fusion HB Module (TDD and FDD)</td>
<td></td>
</tr>
<tr>
<td>B7, B40, B41</td>
<td>QM78064</td>
<td>RF Fusion HB Module (TDD and FDD)</td>
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</tr>
<tr>
<td>Integrated B1, B2, B5, B8/Supporting UMTS/HSPA + LTE Bands</td>
<td>RF7501C</td>
<td>Integrated High-Performance Multi-Band PA</td>
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</tr>
<tr>
<td>Integrated B1, B2 (25), B5, B8/Supporting UMTS/HSPA + LTE Bands</td>
<td>QM77003</td>
<td>Multi-Mode/Multi-Band GSM/EDGE/WCDMA/LTE Transmit Receive Module</td>
<td></td>
</tr>
<tr>
<td>Integrated B1, B2, B5, B8/Supporting UMTS/HSPA + LTE Bands</td>
<td>QM77001E</td>
<td>Multi-Mode/Multi-Band GSM/EDGE/WCDMA/LTE Transmit Receive Module</td>
<td></td>
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</tbody>
</table>

### Transmit Modules

<table>
<thead>
<tr>
<th>Function</th>
<th>Part Number</th>
<th>Description</th>
<th>Band Coverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>SP9T + SP7T</td>
<td>RF5228</td>
<td>RF Flex Tx Module (ASM + Diplexer + 2.5 GPa)</td>
<td>&gt;2.7GHz</td>
</tr>
<tr>
<td>SP5T + SP7T with Dual (SP4T) Antenna Switch</td>
<td>RF5238</td>
<td>RF Flex Tx Module (ASM + Diplexer + 2.5 GPa)</td>
<td>&gt;2.7GHz</td>
</tr>
</tbody>
</table>