

Solving Network Congestion with Carrier Aggregation

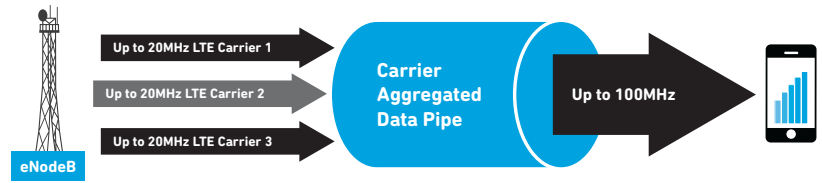
High-performance RF solutions from Qorvo® enable carrier aggregation



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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.



Carrier aggregation combines multiple LTE component carriers to create higher-bandwidth services

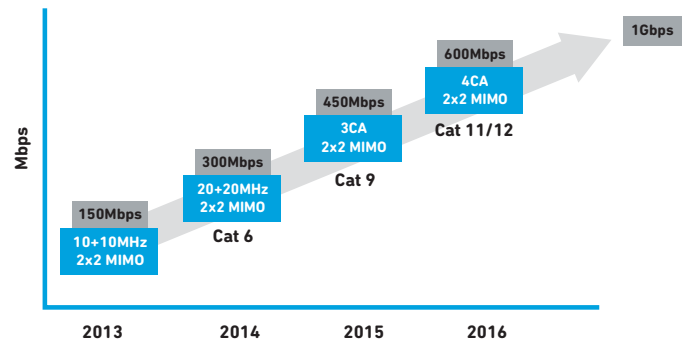
CA is a technique used to combine multiple LTE carrier signals to increase data rates and improve network performance. CA allows increased data rates and improved network performance in the uplink, downlink or both.

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.

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

- 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)

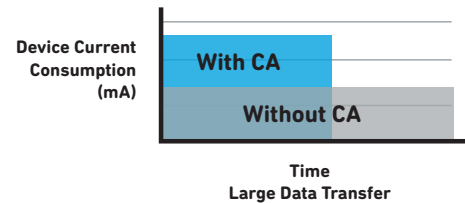


Carrier aggregation data rate evolution for downlink

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.

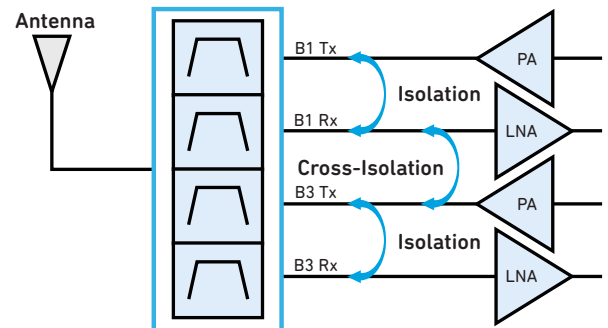


CA increases device power consumption during large downloads

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 LowDrift™ BAW technology is ideally suited to optimize isolation and attenuation performance across bands to help designers mitigate these challenges.



Multiplexer Band 1 & 3

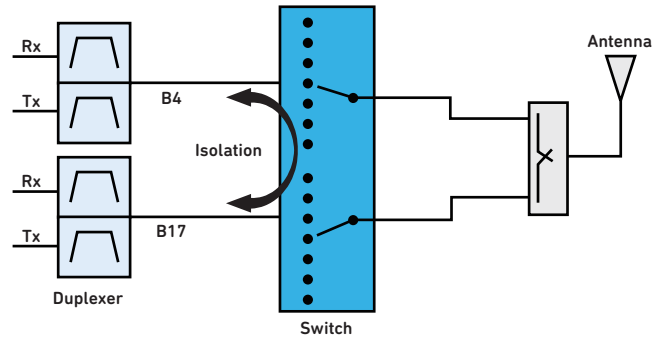
Band 1 + 3 multiplexer requires high isolation between Tx and Rx ports

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.



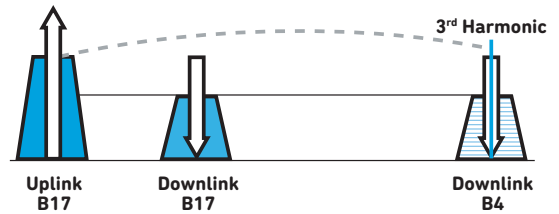
High switch isolation minimizes interference, leakage and desense

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.

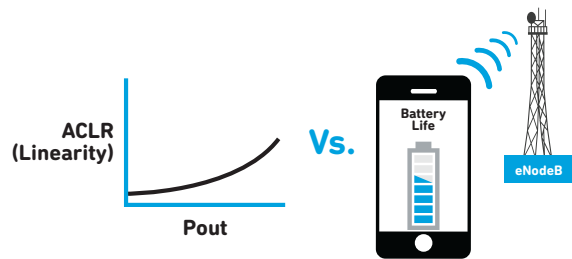
PA – Linearity in the Radio Environment

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.



B17's uplink 3rd harmonic interferes with B4 downlink



Tradeoff between linearity, efficiency and battery life



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

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

Diversity Rx Modules

Function	Part Number	Description	Band Coverage
B25, B66, B3, B7, B39	QM63001A	Diversity Module with Dimpled B25+B66 to Enable CA	4.0x2.7
B1, B3, B25, B7, B39	QM63001	Diversity Module with Dimpled B1+B3 to Enable CA	4.0x2.7

Switch Solutions

Function	Part Number	Description	Band Coverage
SP4T + SP4T	RF1680	Diversity Rx Switch	Up to 3.8GHz
SP6T + SP6T	RF1681	Diversity Rx Switch	Up to 3.8GHz
SP9T + SP7T	RF1682	Diversity Rx Switch	Up to 3.8GHz
SP6T + SP6T	RF1683	Diversity Rx Switch with Integrated Diplexer	Up to 3.8GHz
SP7T + SP7T	RF1890A	Antenna Switch Module	Up to 2.7GHz
SP12T + SP9T	RF1891	Antenna Switch Module	Up to 2.7GHz

Integrated RFFE Modules

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

Transmit Modules

Function	Part Number	Description	Band Coverage
SP9T + SP7T	RF5228	RF Flex Tx Module (ASM + Diplexer + 2.5 GPa)	>2.7GHz
SP5T + SP7T with Dual (SP4T) Antenna Switch	RF5238	RF Flex Tx Module (ASM + Diplexer + 2.5 GPa)	>2.7GHz