CARRIER AGGREGATION WITH THE DIGI CORE 1002-CM LTE MODEM

CARRIER AGGREGATION

Spectrum availability is critical for delivering true 4G connectivity over Long-Term Evolution (LTE) networks. Many locations are reliant upon limited allocations of bandwidth, often as small as 10MHz, which restricts the maximum rate of data transfer available to users. This congestion is exacerbated by the exponential growth of mobile devices both in terms of subscriber quantity and the corresponding increase in traffic per subscribed device.

LTE-Advanced (LTE-A) introduced Carrier Aggregation (CA) to optimize spectrum utilization. Mobile network operators typically broadcast over fragmented band segments that exist as isolated channels (also called carriers). Thanks to CA technology, these separate carriers can be combined to create additional usable bandwidth, facilitating higher data transmission rates as more spectrum is aggregated.

Leveraging CA ensures that mobile networks are operating at maximized efficiency. In addition to providing faster data speeds, lower latency, and broader coverage, operators can dynamically route traffic across an aggregated carrier's constituent channels to implement load balancing without requiring auxiliary service providers. Expanding this technology is a top priority as cellular networks transition from 4G to 5G.

TECHNICAL OVERVIEW

Component Carriers (CCs) are the separate channels that band together to deliver CA. Each can have a bandwidth of 1.4, 3, 5, 10, or 20MHz, and LTE-A standards establish a theoretical maximum of five CCs, thus raising the upper limit of aggregated bandwidth to 100MHz. Since CA bandwidth is the sum of its combined carriers, this hypothetical threshold assumes all five CCs are 20MHz—carriers below 20MHz would detract from the pooled spectrum's peak performance. Furthermore, individual channels can be specifically dedicated to supplement either download or upload activity if necessary, though the number of upload carriers cannot exceed the number of download carriers.

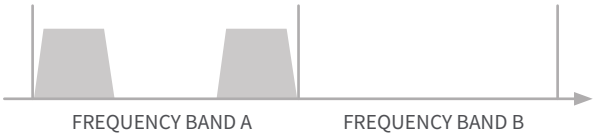
As is the case with LTE itself, CA specified under LTE-A standards supports both Frequency Division Duplex (FDD) and Time Division Duplux (TDD) bands over licensed and unlicensed carrier frequencies. CCs are classified based off of their relative location to each other within the wireless spectrum; they can either be intra-band, as in belonging to the same operating band, or they can be inter-band, indicating that the individual CCs come from separate bands. The intra-band delineation can be further divided into contiguous or non-contiguous CCs depending upon whether or not the aggregated carriers are directly adjacent within the same band.

Intra-band contiguous is the simplest CA scenario from a deployment standpoint, needing only a single transceiver to interface with user equipment, however the competitive state of operator frequency allocations (coupled with the inherently segmented nature of the LTE spectrum) minimizes the availability of adjacent carriers. When contiguous CCs are aggregated, network capacity is increased thanks to the availability of their combined bandwidth funneled through a single signal. Intra-band contiguous CA should become more feasible as new spectrum bands become available for cellular use.

INTRA-BAND CONTIGUOUS

Intra-band non-contiguous CA is prevalent in areas where LTE spectrum is distributed across multiple providers. It leverages channels that share a single band, but unlike contiguous approaches, they aren't situated next to each other on the spectrum. Non-contiguous aggregation necessitates additional transceivers for each CC. This method of aggregation currently serves as the most effective means of combining carriers given how commercial telecom markets are predominantly structured around fragmented spectrum holdings.

INTRA-BAND NON-CONTIGUOUS



Inter-band non-contiguous CA incorporates more than a single operating band to aggregate CCs. It requires even more complex transceivers and algorithms sophisticated enough to process multi-carrier traffic while overcoming the associated increase in signal interference. Although accommodating these difficulties comes at a cost, the boost to spectrum utilization provides even more flexibility when implementing CA solutions.

INTER-BAND NON-CONTIGUOUS

USER IMPACT

Of the potential five CCs outlined by 4G specifications, current cellular infrastructure supports two channels in the majority of locations. LTE-Advanced 3x Carrier Aggregation (3CA) is in its early stages of global deployment, with many wireless service providers rolling out their first wave of 3CA-connected hardware. The list of devices that support 3CA is rather limited, making 2x Carrier Aggregation (2CA) the standard until user equipment catches up with network capabilities.

Category 6 (CAT 6) devices support two CCs allowing for a maximum theoretical data rate of 300Mbps with its 2 x 20MHz CCs. If the CCs are narrower, then the data rate is correspondingly lower. For example, if 10MHz and 20MHz carriers are aggregated, the maximum theoretical data rate is 225Mbps. Even higher bandwidths will be achieved as future generations of wireless user equipment utilize 3- and 4-band aggregations, which will reach peak data rates of 600Mbps (with four carriers).

CONCLUSION

CA introduces a scalable and more efficient use of spectrum to provide end users high-performance cellular data rates and network capacity in both upload and download speeds.

Don't lose critical data! Learn more about the upcoming 2G/3G network shutdowns here.

CARRIER AGGREGATION WITH THE DIGI 1002-CM PLUG-IN LTE MODEM

The CAT 6 version of the Digi 1002-CM plug-in LTE supports:

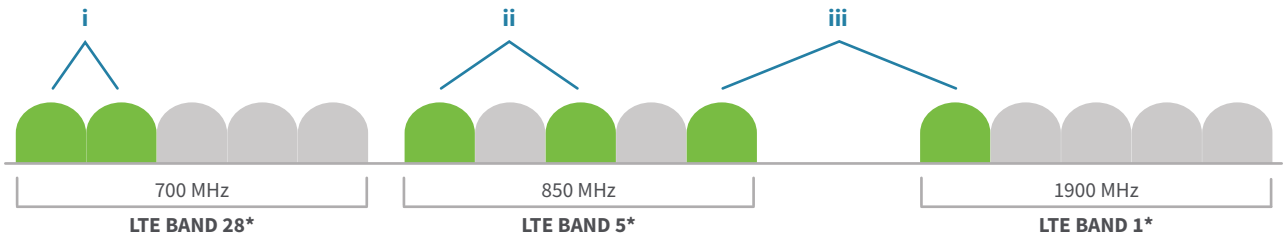
- Intra-band contiguous CA
- Intra-band non-contiguous CA
- Inter-band non-contiguous CA

DIGI 1002-CM CARRIER AGGREGATION

3GPP Release 10 (i), Intra-band contiguous CA

3GPP Release 10 (ii), Intra-band non-contiguous CA

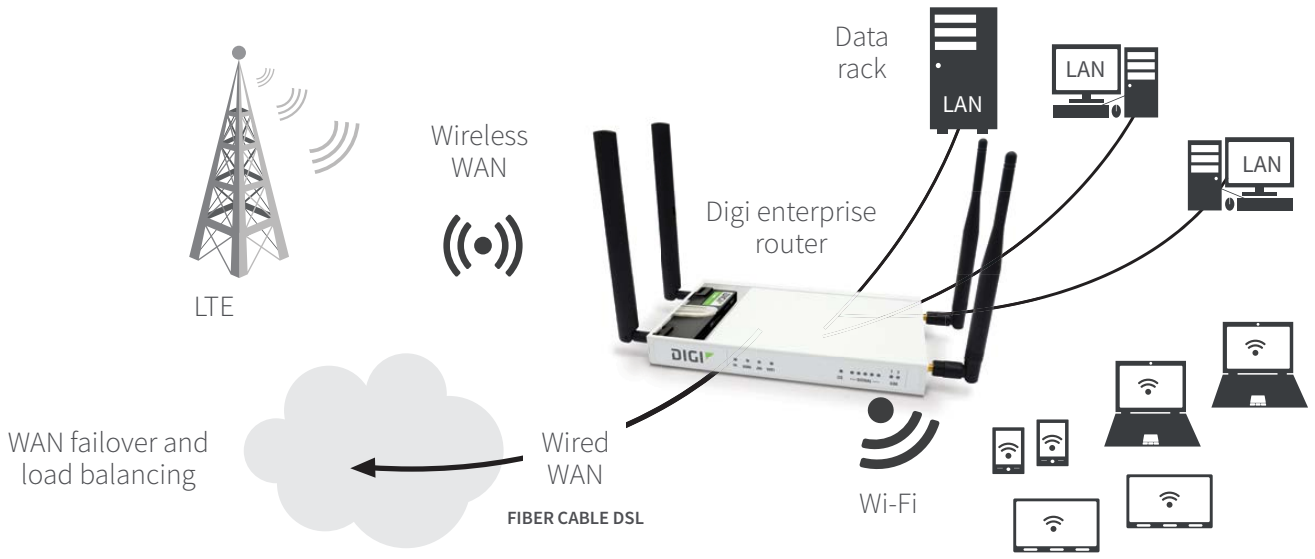
3GPP Release 11 (iii), Inter-band non-contiguous CA



= COMPONENT CARRIER/CHANNEL (CC)
POTENTIAL MAX # NO. OF CC = 5
POTENTIAL MAX B/W = 100 MHz

DIGI 1002-CM SUPPORTS:
MAX # NO. OF CC = 2
MAX B/W = 40 MHz

* Bands named only as examples. Actual bands vary depending on the operator.



DIGI 1002-CM HIGH PERFORMANCE CELLULAR SOLUTION

The Digi 1002-CM plug-in LTE modem provides improved business continuity with high-performance LTE and carrier aggregation. Accelerate your connectivity solutions and eliminate downtime with any Digi enterprise router which all support the Digi 1002-CM, featuring built-in primary or backup cellular connections. Higher speed versions of the Digi 1002-CM will be available in the near future. For more information on Digi enterprise routers, visit www.digi.com. Digi enterprise routers are compact-yet-affordable, enterprise-grade devices that support multiple WAN connectivity options (Ethernet or cellular) as well as load balancing and failover. For large locations and data-intensive applications, a high-speed LTE CAT 6 modem offers the best WWAN connection commercially available.

ABOUT DIGI INTERNATIONAL

Digi International is your mission-critical IoT solutions expert, with the broadest range of wireless transit products, a cloud computing platform tailored for devices, and development services to help customers get to market faster with wireless devices and IoT applications. The entire Digi solution set is tailored to allow any device to communicate with any application, anywhere in the world. Look to Digi for what's next to keep you up to speed and up to date.

DIGI 1002-CM CAT 6 (NORTH AMERICA AND EUROPE): BAND SUPPORT

TECHNOLOGY	SUPPORTED RF BANDS															DATA RATES AND NOTES
	1	2	3	4	5	7	8	12	13	20	25	26	29	30	41	
LTE	**F**	**F**	**F**	**F**	**F**	**F**	**F**	**F**	**F**	**F**	**F**	**F**	**F**	**F**	**T**	**Data rates:** • Downlink (CAT 6): FDD: 300 Mbps, TDD: 222 Mbps • Uplink (CAT 6): FDD: 50 Mbps, TDD: 26 Mbps **Notes:** • Downlink MIMO Support (2x2; 4x2) TDD: 26 Mbps • F=FDD; T=TDD
DC-HSPA+ HSPA+ HSPA UMTS	**Y**	**Y**	**Y**	**Y**	**Y**		**Y**					**N/A**				**Data rates:** • Downlink (CAT 24): Up to 42 Mbps • Uplink (CAT 6): Up to 5.76 Mbps **Notes:** • Diversity support
GNSS	GPS: 1575.42 MHz GLONASS: 1602 MHz BeiDou: 1561.098 MHz Galileo: 1575.42 MHz															

Digi 1002-CM
Family Carrier Aggregation
Carrier Aggregation Combinations

1 + 8

2 + 2/5/12/13/29

3 + 7/20

4 + 4/5/12/13/29

5 + 2/4/30

7 + 3 /7/20

8 + 1

12 + 2 /4/30

13 + 2/4

20 + 3/7

30 + 5/12

41 + 41

USA Carrier Aggregation Combinations

AT&T Combos

AT&T Digi CA combinations are as follows.
The Digi 1002-CM provides full support.
Format is band + band (max spectrum).

- 4 + 12 (30) - supported
- 2 + 12 (30) - supported
- 4 + 29 (20/30) - supported
- 2 + 29 (20/30) - supported
- 2 + 5 (30) - supported
- 4 + 5 (20/30) - supported

Verizon Combos

2-band combo supported today:

- B2 + B13
- B2 + B5
- B4 + B5
- B4 + B2 - Not currently supported

DIGI 1002-CM CAT 6 FOR (ASIA PACIFIC) APAC: BAND SUPPORT

TECHNOLOGY	SUPPORTED RF BANDS															DATA RATES AND NOTES
	1	3	5	6	7	8	9	18	19	21	28	38	39	40	41	
LTE	**F**	**F**	**F**		**F**	**F**		**F**	**F**	**F**	**F**	**T**	**T**	**T**	**T**	**Data rates:** • Downlink (CAT 6): FDD: 300 Mbps, TDD: 222 Mbps • Uplink (CAT 6): FDD: 50 Mbps, TDD: 26 Mbps **Notes:** • Downlink MIMO Support (2x2; 4x2) TDD: 26 Mbps • F=FDD; T=TDD
DC-HSPA+ HSPA+ HSPA UMTS	**Y**	**Y**	**Y**	**Y**		**Y**	**Y**		**Y**		**N/A**					**Data rates:** • Downlink (CAT 24): Up to 42 Mbps • Uplink (CAT 6): Up to 5.76 Mbps **Notes:** • Diversity support
TD-SCDMA													**Y**			**Data rates:** • Downlink: Up to 2.8 Mbps • Uplink: Up to 2.2 Mbps **Notes:** • Downlink: 1.28 Mbps • F=FDD; T=TDD
GNSS	GPS: 1575.42 MHz GLONASS: 1602 MHz BeiDou: 1561.098 MHz Galileo: 1575.42 MHz															

Digi 1002-CM Carrier Aggregation

Carrier Aggregation Combinations

1 + 8/18/19/21

3 + 5/7/19/28

5 + 3/7

7 + 3/5/7/28

8 + 1

18 + 1

19 + 1/3/21

21 + 1/19

28 + 3/7

38 + 38

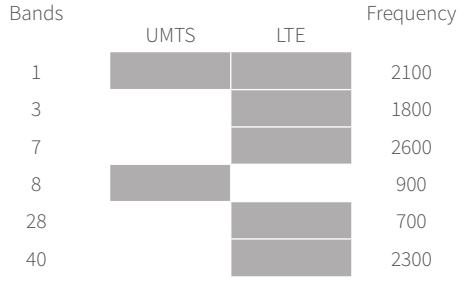
39 + 39

40 + 40

41 + 41

AUSTRALIA BAND SUPPORT

OPTUS



DIGI 1002-CM CAT 6 AUSTRALIA BAND SUPPORT CONTINUED

TELSTRA

Bands	UMTS	LTE	Frequency
1	■	■	2100
3		■	1800
5		■	850
7	■		2600
8		■	900
28		■	700

VODAFONE

Bands	UMTS	LTE	Frequency
1	■	■	2100
3		■	1800
5		■	850
8	■		900

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