

3rd Generation Partnership Project; Technical Specification Group Radio Access Networks; E-UTRA inter-band Carrier Aggregation (Release 12)



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Foreword

This Technical Report has been produced by the 3rd Generation Partnership Project (3GPP).

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

Version x.y.z

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- x the first digit:
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- y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.
- z the third digit is incremented when editorial only changes have been incorporated in the document.

1 Scope

The present document is a technical report for Inter-band Carrier Aggregation under Rel-12 time frame. The purpose is to gather the relevant background information and studies in order to address Inter-band Carrier Aggregation requirements.

This TR covers relevant background information and studies in order to address Inter-band Carrier Aggregation requirements for the Rel-12 band combinations in table 1-1.

Table 1-1: Release 12 inter-band carrier aggregation combinations

WI code	WI title	Class
LTE_CA_B1_B7	LTE Advanced inter-band Carrier Aggregation of Band 1 and Band 7	A3
LTE_CA_B2_B4	LTE Advanced inter-band Carrier Aggregation of Band 2 and Band 4	A4
LTE_CA_B23_B29	LTE Advanced inter-band Carrier Aggregation of Band 23 and Band 29	A1
LTE_CA_B3_B26	LTE Advanced inter-band Carrier Aggregation of Band 3 and Band 26	A1
LTE_CA_B3_B19	LTE Advanced inter-band Carrier Aggregation of Band 3 and Band 19	A1
LTE_CA_B1_B8	LTE Advanced inter-band Carrier Aggregation of Band 1 and Band 8	A1
LTE_CA_B3_B28	LTE Advanced inter-band Carrier Aggregation of Band 3 and Band 28	A1
LTE_CA_B1_B26	LTE Advanced inter-band Carrier Aggregation of Band 1 and Band 26	A1
LTE_CA_B39_B41	LTE Advanced inter-band Carrier Aggregation of Band 39 and Band 41	A3
LTE_CA_B2_B12	LTE Advanced inter-band Carrier Aggregation of Band 2 and Band 12	
LTE_CA_B2_B13	LTE Advanced inter-band Carrier Aggregation of Band 2 and Band 13	
LTE_CA_B19_B21	LTE Advanced inter-band Carrier Aggregation of Band 19 and Band 21	
LTE_CA_B8_B26	LTE Advanced inter-band Carrier Aggregation of Band 8 and Band 26	

This TR contains a general part and band specific combination part. The actual requirements are added to the corresponding technical specifications.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

- [1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".
- [2] 3GPP TR 30.007: "Guideline on WI/SI for new Operating Bands"
- [3] 3GPP TR 36.850: "Inter-band Carrier Aggregation Technical Report (Release 11)"
- [4] 3GPP TS 36.101: "E-UTRA UE radio transmission and reception"
- [5] 3GPP TS 36.331: "E-UTRA UE RRC Protocol specification (Release 11)"

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions given in TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in TR 21.905 [1].

Carrier aggregation: Aggregation of two or more component carriers in order to support wider transmission bandwidths.

Channel bandwidth: The RF bandwidth supporting a single E-UTRA RF carrier with the transmission bandwidth configured in the uplink or downlink of a cell. The channel bandwidth is measured in MHz and is used as a reference for transmitter and receiver RF requirements.

Inter-band carrier aggregation: Carrier aggregation of component carriers in different operating bands.

NOTE: Carriers aggregated in each band can be contiguous or non-contiguous.

3.2 Symbols

For the purposes of the present document, the following symbols apply:

F_{DL_low}	The lowest frequency of the downlink operating band
F_{DL_high}	The highest frequency of the downlink operating band
F_{UL_low}	The lowest frequency of the uplink operating band
F_{UL_high}	The highest frequency of the uplink operating band
R_{IB}	Allowed reference sensitivity relaxation due to support for inter-band CA operation.
$\Delta T_{IB,c}$	Allowed maximum configured output power relaxation due to support for inter-band CA operation, for serving cell c .

3.3 Abbreviations

For the purposes of the present document, the abbreviations given in TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in TR 21.905 [1].

A-MPR	Additional Maximum Power Reduction
BS	Base Station
CA	Carrier Aggregation
CA_X-Y	CA for band X and band Y where X and Y are the applicable E-UTRA operating band
CC	Component Carriers
DL	Downlink
E-UTRA	Evolved UMTS Terrestrial Radio Access
FDD	Frequency Division Duplex
PA	Power Amplifier
REFSENS	Reference Sensitivity power level
TDD	Time Division Duplex
UE	User Equipment
UL	Uplink

4 Background

The present document is a technical report for Inter-band Carrier Aggregation under Rel-12 time frame. It covers both the UE and BS side. The document is divided in two different parts:

- Common part: this part covers BS and UE specific which is band combination independent.

- Specific band combination part: this part covers each band combination and its specific issues independently from each other (i.e. one subclause is defined per band combination)

The specific band combination parts are independent and therefore, the working speed also differs. Annex A contains a list of all CA combinations covered in the present document as well as the status of each WI. The content of each specific combination part can be considered as finalized when the current status of the WI under Annex A is indicated as “Closed”.

4.1 TR Maintenance

A single company is responsible for introducing all approved TPs in the current TR, TR editor. However, it is the responsibility of the rapporteur of each WI to ensure that the TPs related to the WI have been implemented.

5 Inter-band Carrier Aggregation: general part

5.1 BS specific

<Text will be added.>

5.2 UE specific

<Text will be added.>

5.2.1 Class A1. Low-high band combination without harmonic relation between bands or intermodulation problem

<Text will be added.>

5.2.2 Class A2. Low-high band combination with harmonic relation between bands

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5.2.3 Class A3. Low-low or high-high band combination without intermodulation problem (low order IM)

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5.2.4 Class A4. Low-low, low-high or high-high band combination with intermodulation problem (low order IM)

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5.2.5 Class A5. Combination except for A1 – A4

<Text will be added.>

5.3 RRM specific

<Text will be added.>

5.3.1 Class A1. Low-high band combination without harmonic relation between bands or intermodulation problem

<Text will be added.>

6 Inter-band Carrier Aggregation: band combination specific part

6.1 Class A1. Low-high band combination without harmonic relation between bands or intermodulation problem

6.1.1 LTE Advanced Carrier Aggregation of Band 3 and Band 26

Table 6.1.1-1: Inter-band CA operating bands

E-UTRA CA Band	E-UTRA Band	Uplink (UL) band				Downlink (DL) band				Duplex mode
		BS receive / UE transmit				BS transmit / UE receive				
		F _{UL_low} – F _{UL_high}		Channel BW (MHz)		F _{DL_low} – F _{DL_hi} gh		Channel BW (MHz)		
CA_3-26	3	1710 MHz	–	1785 MHz	10, 15, 20	1805 MHz	–	1880 MHz	10, 15, 20	FDD
	26	814 MHz	–	849 MHz	5, 10, 15	859 MHz	–	894 MHz	5, 10, 15	FDD

6.1.1.1 List of specific combination issues

6.1.1.1.1 Channel bandwidths per operating band for CA

Table 6.1.1.1.1-1: Supported E-UTRA bandwidths per CA configuration for inter-band CA

E-UTRA CA Configuration	E-UTRA Bands	CA operating / channel bandwidth						Bandwidth Combination Sets
		1.4 MHz	3 MHz	5 MHz	10 MHz	15 MHz	20 MHz	
CA_3A-26A	3				Yes	Yes	Yes	0
	26			Yes	Yes	Yes		
	3				Yes			1
	26			Yes	Yes			

NOTE: For the UE that signals support of any bandwidth combination set for carrier aggregation, the UE shall support all single carrier bandwidths for the constituent bands as defined in table 5.6.1-1 of TS 36.101 [4] when operating in single carrier mode.

6.1.1.1.2 Co-existence studies for CA_3-26 (1 UL/2 DL)

Table 6.1.1.1.2-1 summarizes frequency ranges where harmonics occur due to Band 3 or Band 26 for both UL and DL. It can be seen that UL harmonic frequencies of Band 3 and Band 26 does not locate within the receive bands of interest in the DL.

Table 6.1.1.1.2-1: Impact of UL/DL Harmonic Interference

Band	UL Low Band Edge	UL High Band Edge	DL Low Band Edge	DL High Band Edge	2 nd Harmonic		3 rd Harmonic		2 nd Harmonic		3 rd Harmonic	
					UL Low Band Edge	UL High Band Edge	UL Low Band Edge	UL High Band Edge	DL Low Band Edge	DL High Band Edge	DL Low Band Edge	DL High Band Edge
3	1710	1785	1805	1880	3420	3570	5130	5355	3610	3760	5415	5640
26	814	849	859	894	1628	1698	2442	2547	1718	1788	2577	2682

6.1.1.1.3 ΔT_{IB} and ΔR_{IB} values

For two simultaneous DL and one UL the $\Delta T_{IB,c}$ and ΔR_{IB} values are shown in table 6.1.1.1.3-1, and in table 6.1.1.1.3-2:

Table 6.1.1.1.3-1: $\Delta T_{IB,c}$

Inter-band CA Configuration	E-UTRA Band	$\Delta T_{IB,c}$ [dB]
CA_3-26	3	0.3
	26	0.3

Table 6.1.1.1.3-2: ΔR_{IB}

Inter-band CA Configuration	E-UTRA Band	ΔR_{IB} [dB]
CA_3-26	3	0
	26	0

6.1.2 LTE Advanced Carrier Aggregation of Band 3 and Band 19 (1 UL)

Table 6.1.2-1: Inter-band CA

E-UTRA CA Band	E-UTRA Band	Uplink (UL) band		Downlink (DL) band		Duplex mode
		BS receive / UE transmit	Channel BW (MHz)	BS transmit / UE receive	Channel BW (MHz)	
		$F_{UL_low} - F_{UL_high}$		$F_{DL_low} - F_{DL_high}$		
CA_3-19	3	1710 MHz – 1785 MHz	5, 10, 15, 20 (note 1)	1805 MHz – 1880 MHz	5, 10, 15, 20	FDD
	19	830 MHz – 845 MHz	5, 10, 15 (note 1)	875 MHz – 890 MHz	5, 10, 15	

NOTE 1: The WI considers only one uplink component carrier to be used in any of the two frequency bands at any time.

6.1.2.1 List of specific combination issues

6.1.2.1.1 Channel bandwidths per operating band for CA

Table 6.1.2.1.1-1: Supported E-UTRA bandwidths per CA configuration for inter-band CA

E-UTRA CA Configuration	E-UTRA Bands	CA operating / channel bandwidth					
		1.4 MHz	3 MHz	5 MHz	10 MHz	15 MHz	20 MHz
CA_3A-19A	3			Yes	Yes	Yes	Yes
	19			Yes	Yes	Yes	

6.1.2.1.2 Co-existence studies for CA_3-19

As band 3 and band 19 are a low-high band combination the harmonic frequencies are far away from the receive and transmit bands of interest in the DL and UL (see table 6.1.2.1.2-1) and therefore we can conclude that there is no issue on harmonic interference.

Table 6.1.2.1.2-1: Impact of UL/DL Harmonic Interference

Band	2 nd Harmonic		3 rd Harmonic		2 nd Harmonic		3 rd Harmonic	
	UL Low Band Edge	UL High Band Edge	DL Low Band Edge	DL High Band Edge	UL Low Band Edge	UL High Band Edge	DL Low Band Edge	DL High Band Edge
3	1710	1785	1805	1880	3420	3570	5130	5355
19	830	845	875	890	1660	1690	2490	2535

6.1.2.1.3 ΔT_{IB} and ΔR_{IB} values

For two simultaneous DL and one UL the $\Delta T_{IB,c}$ and ΔR_{IB} values are shown in table 6.1.2.1.3-1, and in table 6.1.2.1.3-2:

Table 6.1.2.1.3-1: $\Delta T_{IB,c}$

Inter-band CA Configuration	E-UTRA Band	$\Delta T_{IB,c}$ [dB]
CA_3-19	3	0.3
	19	0.3

Table 6.1.2.1.3-2: ΔR_{IB}

Inter-band CA Configuration	E-UTRA Band	ΔR_{IB} [dB]
CA_3-19	3	0
	19	0

6.1.3 LTE Advanced Carrier Aggregation of Band 1 and Band 8 (1 UL)

Table 6.1.3-1: Inter-band CA

E-UTRA CA Band	E-UTRA Band	Uplink (UL) band		Downlink (DL) band		Duplex mode
		BS receive / UE transmit	Channel BW (MHz)	BS transmit / UE receive	Channel BW (MHz)	
		$F_{UL_low} - F_{UL_high}$		$F_{DL_low} - F_{DL_high}$		
CA_1-8	1	1920 MHz – 1980 MHz	5, 10, 15, 20 (note 1)	2110 MHz – 2170 MHz	5, 10, 15, 20	FDD
	8	880 MHz – 915 MHz	5, 10 (note 1)	925 MHz – 960 MHz	5, 10	

NOTE 1: Only one uplink component carrier is to be supported in any of the two frequency bands at any time.

6.1.3.1 List of specific combination issues

6.1.3.1.1 Channel bandwidths per operating band for CA

Table 6.1.3.1.1-1: Supported E-UTRA bandwidths per CA configuration for inter-band CA

E-UTRA CA Configuration	CA operating / channel bandwidth							Bandwidth Combination Set
	E-UTRA Bands	1.4 MHz	3 MHz	5 MHz	10 MHz	15 MHz	20 MHz	
CA_1A-8A	1			Yes	Yes	Yes	Yes	0
	8			Yes	Yes			

	1			Yes	Yes			1
	8			Yes	Yes			

6.1.3.1.2 Co-existence studies for CA_1-8

As shown in table 6.1.3.1.2-1, the harmonic frequencies of band 1 and band 8 in UL are a way from the receive bands of interest in the DL and we can conclude that there is no issue on UL harmonic interference.

Table 6.1.3.1.2-1: Impact of UL Harmonic Interference

Band	UL		DL		2 nd Harmonic		3 rd Harmonic	
	Low Band Edge	High Band Edge	Low Band Edge	High Band Edge	Low Band Edge	High Band Edge	Low Band Edge	High Band Edge
1	1920	1980	2110	2170	3840	3960	5760	5940
18	880	915	925	960	1760	1830	2640	2745

As shown in table 6.1.3.1.2-2, the harmonic frequencies of band 1 and band 8 in UL are a way from the receive bands of interest in the DL and we can conclude that there is no issue on UL harmonic interference.

Table 6.1.3.1.2-2: Band 1 and Band 8 DL harmonics and IMD products

BS DL carriers	f1_low	f1_high	f2_low	f2_high
DL frequency (MHz)	925	960	2110	2170
2 nd order harmonics frequency range (MHz)	1850	1920	4220	4340
3 rd order harmonics frequency range (MHz)	2775	2880	6330	6510
2 nd order IMD products	(f2_low – f1_high)	(f2_high – f1_low)	(f2_low + f1_low)	(f2_high + f1_high)
IMD frequency limits (MHz)	925	960	2110	2170
3 rd order IMD products	(f2_low – 2*f1_high)	(f2_high – 2*f1_low)	(2*f2_low – f1_high)	(2*f2_high – f1_low)
IMD frequency limits (MHz)	190	320	3260	3415
3 rd order IMD products	(2*f1_low + f2_low)	(2*f1_high + f2_high)	(2*f2_low + f1_low)	(2*f2_high + f1_high)
IMD frequency limits (MHz)	3960	4090	5145	5300
3 rd order IMD products	(f1_low – max BW f2)	(f1_high + max BW f2)	(f2_low – max BW f1)	(f2_high + max BW f1)
IMD frequency limits (MHz)	905	980	2100	2180

It can be seen from table 6.1.3.1.2-1 that the upper edge of the 2nd harmonics of BS transmit band of f1 (band 8) is on the lower edge of BS receive band of f2 (band 1). It can also be seen that the 3rd IMD falls into BS receive band of band 8. However, as noted in subclause 5.1, this issue can be regarded as covered in co-located BS scenarios and there is no need to address in Inter-band carrier aggregation context.

6.1.3.1.3 $\Delta T_{IB,c}$ and ΔR_{IB} values

For two simultaneous DL and only one UL, the tentative $\Delta T_{IB,c}$ and ΔR_{IB} values are given in the tables below.

Table 6.1.3.1.3-1: $\Delta T_{IB,c}$

Inter-band CA Configuration	E-UTRA Band	$\Delta T_{IB,c}$ [dB]
CA_1A-8A	1	0.3
	8	0.3
NOTE: The values in the table reflect what can be achieved with the present state of the art technology. They shall be reconsidered when the state of the art technology progresses		

Table 6.1.3.1.3-2: ΔR_{IB}

Inter-band CA Configuration	E-UTRA Band	ΔR_{IB} [dB]
CA_1A-8A	1	0
	8	0

6.1.4 LTE Advanced Carrier Aggregation of Band 3 and Band 28 (1 UL)

Table 6.1.4-1: Inter-band CA

E-UTRA CA Band	E-UTRA Band	Uplink (UL) band		Downlink (DL) band		Duplex mode
		BS receive / UE transmit	Channel BW (MHz)	BS transmit / UE receive	Channel BW (MHz)	
		F _{UL_low} – F _{UL_high}		F _{DL_low} – F _{DL_high}		
CA_3-28	3	1710 MHz – 1785 MHz	5, 10, 15, 20 (note 1)	1805 MHz – 1880 MHz	5, 10, 15, 20	FDD
	28	703 MHz – 748 MHz	5, 10, 15, 20 (note 1)	758 MHz – 803 MHz	5, 10, 15, 20	

NOTE 1: The WI considers only one uplink component carrier to be used in any of the two frequency bands at any time.

6.1.4.1 List of specific combination issues

6.1.4.1.1 Channel bandwidths per operating band for CA

Table 6.1.4.1.1-1: Supported E-UTRA bandwidths per CA configuration for inter-band CA

E-UTRA CA Configuration	E-UTRA Bands	CA operating / channel bandwidth					
		1.4 MHz	3 MHz	5 MHz	10 MHz	15 MHz	20 MHz
CA_3A-28A	3			Yes	Yes	Yes	Yes
	28			Yes	Yes	Yes	Yes

6.1.4.1.2 Co-existence studies for CA_3-28

As band 3 and band 28 are a low-high band combination the harmonic frequencies are far away from the receive bands of interest in the DL (see table 6.1.4.1.2-1) and we can conclude that there is no issue on harmonic interference.

Table 6.1.4.1.2-1: Band 3 and Band 28 UL harmonics

Band	UL Low Band Edge	UL High Band Edge	DL Low Band Edge	DL High Band Edge	2 nd Harmonic		3 rd Harmonic	
					UL Low Band Edge	UL High Band Edge	UL Low Band Edge	UL High Band Edge
3	1710	1785	1805	1880	3420	3570	5130	5355
28	703	748	758	803	1406	1496	2109	2244

The 2nd and 3rd order harmonics and IMD products caused in the BS by transmitting of band 3 and band 28 DL carriers can be calculated as shown in table 6.1.4.1.2-1 below:

Table 6.1.4.1.2-2: Band 3 and Band 28 DL harmonics and IMD products

BS DL carriers	f1_low	f1_high	f2_low	f2_high
DL frequency (MHz)	758	803	1805	1880
2 nd order harmonics frequency range (MHz)	1516	1606	3610	3760
3 rd order harmonics frequency range (MHz)	2274	2409	5415	5640
2 nd order IMD products	(f2_low – f1_high)	(f2_high – f1_low)	(f2_low + f1_low)	(f2_high + f1_high)
IMD frequency limits (MHz)	1002	1122	2563	2683
3 rd order IMD products	(f2_low – 2*f1_high)	(f2_high – 2*f1_low)	(2*f2_low – f1_high)	(2*f2_high – f1_low)
IMD frequency limits (MHz)	199	364	2807	3002
3 rd order IMD products	(2*f1_low + f2_low)	(2*f1_high + f2_high)	(2*f2_low + f1_low)	(2*f2_high + f1_high)
IMD frequency limits (MHz)	3321	3486	4368	4563
3 rd order IMD products	(f1_low – max BW f2)	(f1_high + max BW f2)	(f2_low – max BW f1)	(f2_high + max BW f1)
IMD frequency limits (MHz)	683	878	1760	1925

It can be seen that the 3rd IMD falls into BS receive band of band 3 and 28. However, these products will not fall into the BS own receive block if the frequency range as defined with the channel bandwidths given in table 6.1.4.1.1-1 are used for the more detailed IMD calculation.

6.1.4.1.3 $\Delta T_{IB,c}$ and ΔR_{IB} values

For two simultaneous DL and only one UL, the tentative $\Delta T_{IB,c}$ and ΔR_{IB} values are given in the tables below.

Table 6.1.4.1.3-1: $\Delta T_{IB,c}$

Inter-band CA Configuration	E-UTRA Band	$\Delta T_{IB,c}$ [dB]
CA_3A-28A	3	0.3
	8	0.3
NOTE: The values in the table reflect what can be achieved with the present state of the art technology. They shall be reconsidered when the state of the art technology progresses		

Table 6.1.4.1.3-2: ΔR_{IB}

Inter-band CA Configuration	E-UTRA Band	ΔR_{IB} [dB]
CA_3A-28A	3	0
	8	0

6.1.5 LTE Advanced Carrier Aggregation of Band 1 and Band 26

CA_1-26 is designed to operate in the operating bands defined in Table 6.1.5-1.

Table 6.1.5-1: Inter band CA operating bands

E-UTRA CA Band	E-UTRA Band	Uplink (UL) band				Downlink (DL) band				Duplex mode
		BS receive / UE transmit			Channel BW (MHz)	BS transmit / UE receive			Channel BW (MHz)	
		F _{UL_low}	–	F _{UL_high}		F _{DL_low}	–	F _{DL_high}		
CA_1-26	1	1920 MHz	–	1980 MHz	5, 10, 15, 20	2110 MHz	–	2170 MHz	5, 10, 15, 20	FDD
	26	814 MHz	–	849 MHz	5, 10, 15	859 MHz	–	894 MHz	5, 10, 15	FDD

6.1.5.1 List of specific combination issues

6.1.5.1.1 Channel bandwidths per operating band for CA

Table 6.1.5.1.1-1: Supported E-UTRA bandwidths per CA configuration for inter-band CA

CA operating / channel bandwidth							
E-UTRA CA Configuration	E-UTRA Bands	1.4 MHz	3 MHz	5 MHz	10 MHz	15 MHz	20 MHz
CA_1A-26A	1			Yes	Yes	Yes	Yes
	26			Yes	Yes	Yes	

6.1.5.1.2 Co-existence studies for CA_1-26

Although Band 1 and Band 26 are a High-Low band combination, the harmonic frequencies do not fall into the frequency ranges of both bands as observed in Table 6.1.5.1.2-1. Therefore we can conclude that there is no issue on harmonic interference.

Table 6.1.5.1.2-1: Impact of UL/DL Harmonic Interference

Band	UL Low Band Edge	UL High Band Edge	DL Low Band Edge	DL High Band Edge	2 nd Harmonic		3 rd Harmonic		2 nd Harmonic		3 rd Harmonic	
					UL Low Band Edge	UL High Band Edge	UL Low Band Edge	UL High Band Edge	DL Low Band Edge	DL High Band Edge	DL Low Band Edge	DL High Band Edge
1	1920	1980	2110	2170	3840	3960	5760	5940	4220	4340	6330	6510
26	814	849	859	894	1628	1698	2442	2547	1718	1788	2577	2682

Table 6.1.5.1.2-2 gives the frequency range of the third and fifth order intermodulation products when two simultaneous DLs are active in Band 1 and band 26. It can be seen that the intermodulation products are not falling within the two inter-bands and therefore no further relaxation is needed.

Table 6.1.5.1.2-2: Third order and fifth order intermodulation products (DL)

Band	DL low band edge	DL high band edge	DL 3 rd order products	DL 5 th order products
1	2110 MHz	2170 MHz	N/A	N/A
26	859 MHz	894 MHz	3326 – 3481 MHz	4542 – 4792 MHz

6.1.5.1.3 ΔT_{IB} and ΔR_{IB} values

Following relaxations are allowed for the UE which supports inter-band carrier aggregation of Band 1 and Band 26.

Table 6.1.5.1.3-1: $\Delta T_{IB,c}$

Inter-band CA Configuration	E-UTRA Band	$\Delta T_{IB,c}$ [dB]
CA_1A-26A	1	0.3
	26	0.3

Table 6.1.5.1.3-2: ΔR_{IB}

Inter-band CA Configuration	E-UTRA Band	$\Delta R_{IB,c}$ [dB]
CA_1A-26A	1	0
	26	0

6.2 Class A2. Low-high band combination with harmonic relation between bands

<Text will be added.>

6.3 Class A3. Low-low or high-high band combinations

6.3.1 LTE-Advanced Carrier Aggregation of Band 1 and Band 7 (1 UL)

Table 6.3.1-1: Inter-band CA

E-UTRA CA Band	E-UTRA operating Band	Uplink (UL) band			Downlink (DL) band			Duplex mode		
		UE transmit / BS receive		Channel BW MHz	UE receive / BS transmit		Channel BW MHz			
		FUL_low	FUL_high		FDL_low	FDL_high				
CA_1-7	1	1920 MHz	–	1980 MHz	15	2110 MHz	–	2170 MHz	15	FDD
	7	2500 MHz	–	2570 MHz	15, 20	2620 MHz	–	2690 MHz	15, 20	

6.3.1.1 List of specific combination issues

6.3.1.1.1 Channel bandwidths per operating band for CA

Table 6.3.1.1.1-1: Supported E-UTRA bandwidths per CA configuration for inter-band CA

E-UTRA CA Configuration	E-UTRA Bands	CA operating / channel bandwidth					
		1.4 MHz	3 MHz	5 MHz	10 MHz	15 MHz	20 MHz
CA_1A-7A	1					Yes	
	7					Yes	Yes

6.3.1.1.2 Co-existence studies for 1UL/2DL

Table 6.3.1.1.2-1 gives the intermodulation products for band 1 + band 7 CA with 2DLs. For the 3-tone IMD analysis the maximum transmission as defined in table 6.3.1.1.1-1 is considered. Three-tone third order IMD products will not fall into the BS own receive block if the frequency range as defined with the channel bandwidths given in table 6.3.1.1.1-1 are used for the more detailed IMD calculation.

Considering bands in the same geographical area we observe that the BS distortion could fall into the BS receive bands of band 3. With the performances of the current BS antenna system, transmit and receive path components, amplifiers, pre-distortion algorithms and filters the IMDs generated within the band 3 receiver should be well below the receiver noise floor eliminating the possibility of receiver desensitization. Provided that the bands 1 and 7 BS transmitters should not share the same antenna with band 3 BS receiver.

Table 6.3.1.1.2-1: 2DLs B1 + B7 IMD products

BS DL carriers	f1_low	f1_high	f2_low	f2_high
DL frequency (MHz)	2110	2170	2620	2690
2 nd order harmonics frequency range (MHz)	4220 to 4340		5240 to 5380	
3 rd order harmonics frequency range (MHz)	6330 to 6510		7860 to 8070	
Two-tone 2 nd order IMD products	$ f2_low - f1_high $	$ f2_high - f1_low $	$ f2_low + f1_low $	$ f2_high + f1_high $
IMD frequency range (MHz)	450 to 580		4730 to 4860	
Two-tone 3 rd order IMD products	$ 2*f1_low - f2_high $ & $(2*f1_low + f2_low)$	$ 2*f1_high - f2_low $ & $(2*f1_high + f2_high)$	$ 2*f2_low - f1_high $ & $(2*f2_low + f1_low)$	$ 2*f2_high - f1_low $ & $(2*f2_high + f1_high)$
IMD frequency range (MHz)	1530 to 1720 6840 to 7030		3070 to 3270 7350 to 7550	
Three-tone 3 rd order IMD products	$(f1_low - \max BW f2)$	$(f1_high + \max BW f2)$	$(f2_low - \max BW f1)$	$(f2_high + \max BW f1)$
IMD frequency range (MHz)	2090 to 2190		2605 to 2705	

Table 6.3.1.1.2-2 gives the intermodulation products for band 1+ band 7 CA with 1UL. None of the intermodulation products fall into the own and any other receive bands.

Table 6.3.1.1.2-2: 1UL B1 + B7 harmonic products

UE UL carriers	f1_low	f1_high	f2_low	f2_high
UL frequency (MHz)	1920	1980	2500	2570
2 nd order harmonics frequency range (MHz)	3840 to 3960		5000 to 5140	
3 rd order harmonics frequency range (MHz)	5760 to 5940		7500 to 7710	

6.3.1.1.3 ΔT_{IB} and ΔR_{IB} values

The reported additional IL (Insertion Loss) values, based on implementation/simulation data, under ETC (Extreme Temperature Conditions) for combining band 1 and band 7, for each of the Tx and Rx paths, are shown in table 6.3.1.1.3-1.

Table 6.3.1.1.3-1: IL values for band 1 + 7 diplexer and quadplexers (under ETC)

E-UTRA bands	IL (dB)	IL (dB)	IL (dB)	IL (dB) (Note 1)
1 Tx	0.4	0.7	0.4	1.2
1 Rx	0.37	0.7	0.2	1.4
7 Tx	0.63	1.2	0.7	1.2
7 Rx	0.58	1.2	0.4	0.6

NOTE 1: The values for this device are reported under nominal conditions.

For the reported additional IL values, the corresponding average additional IL values for the Tx and the Rx paths, from [2], are shown in table 6.3.1.1.3-2:

Table 6.3.1.1.3-2: Average Tx and Rx IL for combining band 1 and band 7 (under ETC)

Inter-band CA Configuration	E-UTRA Band	Tx IL [dB]	Rx IL [dB]
\bar{IL}	1	[FFS]	[FFS]
	7	[FFS]	[FFS]

For two simultaneous DLs and one UL the $\Delta T_{IB,c}$ and ΔR_{IB} values, from [2], are shown in table 6.3.1.1.3-3, and in table 6.3.1.1.3-4:

Table 6.3.1.1.3-3: $\Delta T_{IB,c}$

Inter-band CA Configuration	E-UTRA Band	$\Delta T_{IB,c}$ [dB]
CA_1A-7A	1	[FFS]
	7	[FFS]

Table 6.3.1.1.3-4: $\Delta R_{IB,c}$

Inter-band CA Configuration	E-UTRA Band	ΔR_{IB} [dB]
CA_1A-7A	1	[FFS]
	7	[FFS]

6.3.2 LTE-Advanced Carrier Aggregation of Band 39 and Band 41

Table 6.3.2-1: Inter-band CA

E-UTRA CA Band	E-UTRA Band	Uplink (UL) band		Downlink (DL) band		Duplex mode
		BS receive / UE transmit	Channel BW (MHz)	BS transmit / UE receive	Channel BW (MHz)	
		F_{UL_low} – F_{UL_high}		F_{DL_low} – F_{DL_high}		
CA_39-41	39	1880 MHz – 1920 MHz	10, 15, 20 (note 1)	1880 MHz – 1920 MHz	10, 15, 20	TDD
	41	2496 MHz – 2690 MHz	20 (note 1)	2496 MHz – 2690 MHz	20	

NOTE 1: The first part of the WI considers only one uplink component carrier to be used in any of the two frequency bands at any time.

6.3.2.1 List of specific combination issues

6.3.2.1.1 Channel bandwidths per operating band for CA

Table 6.3.2.1.1-1: Supported E-UTRA bandwidths per CA configuration for inter-band CA

E-UTRA CA Configuration	E-UTRA Bands	CA operating / channel bandwidth					
		1.4 MHz	3 MHz	5 MHz	10 MHz	15 MHz	20 MHz
CA_39-41A	39				Yes	Yes	Yes
	41						Yes

6.3.2.1.2 Co-existence studies for 1UL/2DL

Table 6.3.2.1.2-1 gives the intermodulation products for band 39 + band 41 CA with 2 DLs. For the 3-tone IMD analysis the maximum transmission as defined in table 6.3.2.1.1-1 is considered. None of the harmonics of one band fall into the receive band of the other. The intermodulation products generated by two operating bands do not impact the own receiver since TDD BS cannot transmit and receive simultaneously in a single band.

We have listed all the possible interference to other operating bands in table 6.3.2.1.2-2. It can be seen in the table that 2nd order harmonics may fall into BS receive band of band 43, two-tone 2nd order IMD products may fall into BS receive band of band 12, 13, 14, 17, 27, 28, 44, two-tone 3rd order IMD products may fall into BS receive band of band 22 and band 42, and three-tone 3rd order IMD products caused by BS supporting carrier aggregation of band 39 and band 41 may fall into the BS receive band of band 1, 2, 7, 25, 33, 35, 36, 37, 38.

Currently Bands 1, 42 and 44 are used in the same geographical area as Bands 39 and 41. With the performances of the current BS antenna system, transmit and receive path components, amplifiers, pre-distortion algorithms and filters, it is expected that the IMD interference generated within the Band 1, 42 or 44 receiver would be well below the receiver noise floor, in order to avoid the possibility of receiver desensitization. Thus it is recommended that Bands 39 and 41

BS transmitters do not share the same antenna with Band 1, 42 or 44 BS receivers, unless the antenna path meets more stringent 2nd and 3rd order PIM specification so that the PIM will not cause Band 1, 42 or 44 BS receivers desensitization. Note that antenna sharing may be allowed as the state-of-the-art continues to evolve in the future.

Table 6.3.2.1.2-1: 2 DLs B39 + B41 harmonics and IMD products frequency limits

BS DL carriers	f1_low	f1_high	f2_low	f2_high
DL frequency (MHz)	1880	1920	2496	2690
2 nd order harmonics frequency range (MHz)	3760 to 3840		4992 to 5380	
3 rd order harmonics frequency range (MHz)	5640 to 5760		7488 to 8070	
Two-tone 2 nd order IMD products	f2_low – f1_high	f2_high – f1_low	f2_low + f1_low	f2_high + f1_high
IMD frequency range (MHz)	575 to 810		4376 to 4610	
Two-tone 3 rd order IMD products	2*f1_low – f2_high	2*f1_high – f2_low	2*f2_low – f1_high	2* f2_high – f1_low
IMD frequency range (MHz)	1070 to 1344		3072 to 3500	
Three-tone 3 rd order IMD products	f1_low – max BW f2	f1_high + max BW f2	f2_low – max BW f1	f2_high + max BW f1
IMD frequency range (MHz)	1860 to 1940		2476 to 2710	

Table 6.3.2.1.2-2: possible interference to other bands

Victim Bands	Receiver frequency range (MHz)	Interference type	Interference frequency range (MHz)
Band 1	1920 to 1980	Three-tone 3 rd order IMD products	1860 to 1940
Band 2	1850 to 1910	Three-tone 3 rd order IMD products	1860 to 1940
Band 7	2500 to 2570	Three-tone 3 rd order IMD products	2476 to 2710
Band 12	699 to 716	Two-tone 2 nd order IMD products	576 to 810
Band 13	777 to 787	Two-tone 2 nd order IMD products	576 to 810
Band 14	788 to 798	Two-tone 2 nd order IMD products	576 to 810
Band 17	704 to 716	Two-tone 2 nd order IMD products	576 to 810
Band 22	3410 to 3490	Two-tone 3 rd order IMD products	3072 to 3500
Band 25	1850 to 1915	Three-tone 3 rd order IMD products	1860 to 1940
Band 27	807 to 824	Two-tone 2 nd order IMD products	576 to 810
Band 28	703 to 748	Two-tone 2 nd order IMD products	576 to 810
Band 33	1900 to 1920	Three-tone 3 rd order IMD products	1860 to 1940
Band 35	1850 to 1910	Three-tone 3 rd order IMD products	1860 to 1940
Band 36	1930 to 1990	Three-tone 3 rd order IMD products	1860 to 1940
Band 37	1910 to 1930	Three-tone 3 rd order IMD products	1860 to 1940
Band 38	2570 to 2620	Three-tone 3 rd order IMD products	2476 to 2710
Band 42	3400 to 3600	Two-tone 3 rd order IMD products	3072 to 3500
Band 43	3600 to 3800	2 nd order harmonics	3760 to 3840
Band 44	703 to 803	Two-tone 2 nd order IMD products	576 to 810

Table 6.3.2.1.2-3 gives the harmonic products for band 39 + band 41 CA with 1 UL. None of the harmonic products fall into the own receive bands. For the UE, the distortion of band 39 could fall into the UE receive bands for band 43. As currently there is no deployment for band 39&41 and band 43 in the same geographical area, and a UE does not operate simultaneously in B39 + B41 and band 43, this should be not a problem in case the UE supports this band.

Table 6.3.2.1.2-3: 1 UL B39 + B41 harmonic products

UE UL carriers	f1_low	f1_high	f2_low	f2_high
UL frequency (MHz)	1880	1920	2496	2690
2 nd order harmonics frequency range (MHz)	3760 to 3840		4992 to 5380	
3 rd order harmonics frequency range (MHz)	5640 to 5760		7488 to 8070	

6.3.2.1.3 UEs supporting or not supporting simultaneous reception and transmission

According to TS 36.331[5], for inter-band TDD CA, there is an element simultaneousRx-Tx in the IE UE-EUTRA-Capability described as following.

simultaneousRx-Tx

Indicates whether the UE supports simultaneous reception and transmission on different bands for each band combination listed in supportedBandCombination. This field is only applicable for inter-band TDD carrier aggregation.

According to this capability, there will be two kinds of UEs for inter-band TDD carrier aggregation, i.e. the UE supporting simultaneous reception and transmission on different bands and the UE not supporting simultaneous reception and transmission on different bands.

6.4 Class A4. Low-low, low-high or high-high band combination with intermodulation problem (low order IM)

<Text will be added.>

6.4.1 LTE Advanced Carrier Aggregation of Band 2 and Band 4

6.4.1.1 Channel bandwidths per operating band for CA

LTE inter-band carrier aggregation configuration CA_2A-4A shall be operated in E-UTRA CA band CA_2-4 as specified in table 6.4.1.1-1.

Table 6.4.1.1-1: CA_2-4 operating bands

E-UTRA CA Band	E-UTRA Band	Uplink (UL) operating band			Downlink (DL) operating band		
		BS receive / UE transmit			BS transmit / UE receive		
		F _{UL_low}	–	F _{UL_high}	F _{DL_low}	–	F _{DL_high}
CA_2-4	2	1850 MHz	–	1910 MHz	1930 MHz	–	1990 MHz
	4	1710 MHz	–	1755 MHz	2110 MHz	–	2155 MHz

LTE inter-band carrier aggregation configuration CA_2A-4A shall be operated with E-UTRA channel bandwidths as specified in table 6.4.1.1-2

Table 6.4.1.1-2: CA_2A-4A channel bandwidths

CA operating / channel bandwidth							
E-UTRA CA Configuration	E-UTRA Bands	1.4 MHz	3 MHz	5 MHz	10 MHz	15 MHz	20 MHz
CA_2A-4A	2	Yes	Yes	Yes	Yes	Yes	
	4			Yes	Yes	Yes	

6.4.1.2 BS co-existence studies for CA_2-4

Table 6.4.1.2-1 shows harmonics frequency limits and table 6.4.1.2-2 intermodulation products frequency limits for CA of Band 2 and Band 4, respectively.

Table 6.4.1.2-1: DL harmonics frequency limits for CA of Band 2 and Band 4

BS DL carriers	f _{1_low}	f _{1_high}	f _{2_low}	f _{2_high}
DL frequency (MHz)	1930	1990	2110	2155
2 nd order harmonics frequency range (MHz)	3860 to 3980		4220 to 4310	
3 rd order harmonics frequency range (MHz)	5790 to 5970		6330 to 6465	

As shown in table 6.4.1.2-1, no second and no third harmonics will fall to any 3GPP UL frequencies.

Table 6.4.1.2-2: DL intermodulation products frequency limits for CA of Band 2 and Band 4

BS DL carriers	f1_low	f1_high	f2_low	f2_high
DL frequency (MHz)	1930	1990	2110	2155
Two-tone 2 nd order IMD products	$ f2_low - f1_high $	$ f2_high - f1_low $	$ f2_low + f1_low $	$ f2_high + f1_high $
IMD frequency range (MHz)	120 to 225		4040 to 4145	
Two-tone 3 rd order IMD products	$ 2*f1_low - f2_high $	$ 2*f1_high - f2_low $	$ 2*f2_low - f1_high $	$ 2*f2_high - f1_low $
IMD frequency range (MHz)	1705 to 1870		2230 to 2380	
Three-tone 3 rd order IMD products	$(f1_low - \text{max BW } f2)$	$(f1_high + \text{max BW } f2)$	$(f2_low - \text{max BW } f1)$	$(f2_high + \text{max BW } f1)$
IMD frequency range (MHz)	1915 to 2005		2095 to 2170	

As shown in table 6.4.1.2-2, no second order intermodulation products will fall to any 3GPP UL frequencies. Third intermodulation products may fall to UL frequencies of Bands 1-4, 9-10, 23, 25, 33, 35-37, 39 or 40. As third intermodulation products may fall to own receive block (both for Band 2 and Band 4, highlighted in table 6.4.1.2-2), the desensitisation may be an issue.

Analysis in table 6.4.1.2-2 assumes BS is transmitting the whole DL frequency for both Band 2 and Band 4. Further analysis were made when two-tone third order intermodulation product will fall to own receive block for CC bandwidths agreed in the Work Item Description (WID): 5MHz, 10MHz and 15MHz for both operating bands plus 1.4 and 3MHz for Band 2. Two-tone third order intermodulation products were summarized in table 6.4.1-3 with assumptions shown in figure 6.4.1.2-1.

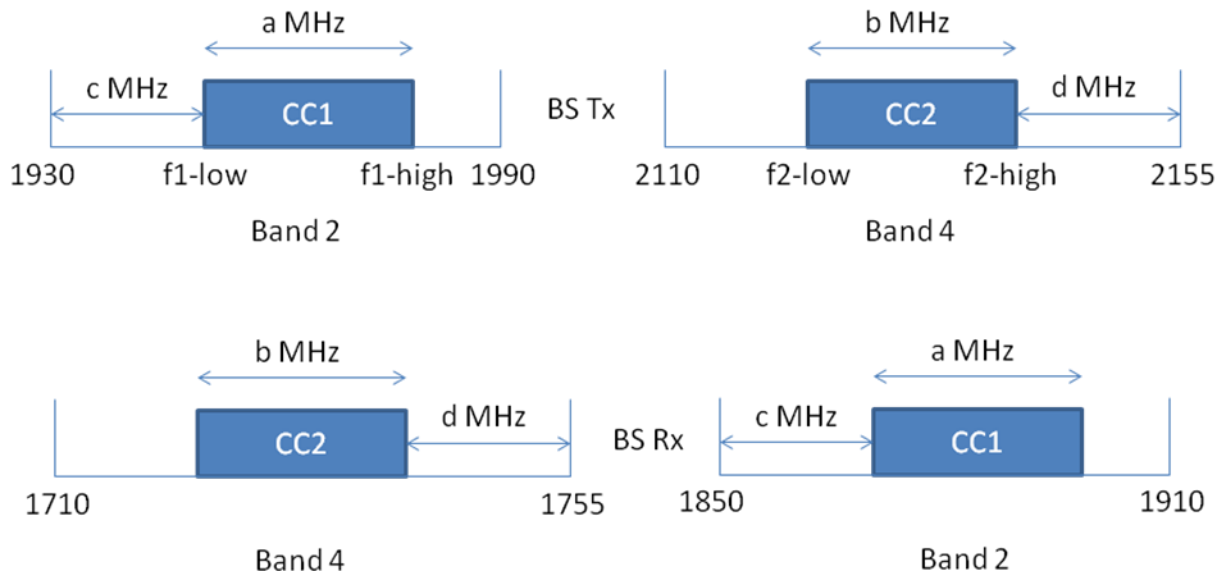


Figure 6.4.1.2-1: Assumptions for third intermodulation products analysis

Table 6.4.1.2-3: Two-tone third order IMD products frequency limits for CA of Band 2 and Band 4

Two-tone 3 rd order IMD products	IMD frequency range (MHz)
$2*f1_low - f2_high$	$1705 + 2*c + d$
$2*f1_high - f2_low$	$1705 + 2*c + 2*a + b + d$

Taking into account CC bandwidths agreed in the WID, two-tone third order intermodulation product will fall to own receive block for CC1 and CC2 positions summarized in table 6.4.1.2-4. Considered scenarios are very pessimistic as studies are taking into account channel bandwidths. Taking into account transmission bandwidths (1.08, 2.7, 4.5, ... MHz) the region where IMD would fall to receive band would be further reduced.

Table 6.4.1.2-4: CC1 and CC2 positions for two-tone third order IMD product falling to own receive block

CC1 bandwidth (a in MHz)	CC2 bandwidth (b in MHz)	CC1 and CC2 positions (c + d in MHz)
1.4	5	$25 > c + d > 18.6$
1.4	10	$25 > c + d > 13.6$
1.4	15	$25 > c + d > 8.6$
3	5	$25 > c + d > 17$
3	10	$25 > c + d > 12$
3	15	$25 > c + d > 7$
5	5	$25 > c + d > 15$
5	10	$25 > c + d > 10$
5	15	$25 > c + d > 5$
10	5	$25 > c + d > 10$
10	10	$25 > c + d > 5$
10	15	$25 > c + d > 0$
15	5	$25 > c + d > 5$
15	10	$25 > c + d > 0$
15	15	$25 > c + d \geq 0$

It is suggested BS transmitters supporting CA of Band 2 and Band 4 should not share the same antenna with Band 1, 2, 3, 4, 9, 10, 23, 25, 33, 35-37, 39 or 40 BS receiver, unless the antenna path meets very stringent third order PIM specification so that the PIM will not cause Band 1, 2, 3, 4, 9, 10, 23, 25, 33, 35-37, 39 or 40 BS receiver desensitization.

6.4.1.3 UE Co-existence studies for CA_2-4

The scope of the WID states that the specifications are done for 1 UL operation. Because of that IMD studies between the UL bands are not required for now. Study of UL 2nd and 3rd order harmonics frequencies is needed. Results of the harmonic study are presented in table 2.2-1. It can be observed that none of the 2nd or 3rd harmonic products fall into own DL bands. It can be noted that band 4 second harmonic extends to 3510 MHz which is the start frequency for band 22 and some harmonic power might land on band 22. Band 4 second harmonic also falls to band 42. Band 2 second harmonic falls to band 43.

Table 6.4.1.3-1: Harmonic analysis for UE UL

	Order of harmonics	Harmonic frequency range / MHz	
Band 2	2nd harmonic range	3700	3820
Band 4	2nd harmonic range	3420	3510
Band 2	3rd harmonic range	5550	5730
Band 4	3rd harmonic range	5130	5265

6.4.1.4 $\Delta T_{IB,c}$ and ΔR_{IB} values

The following additional ILs for combining band 2+4 were reported by two filter manufacturers. Simulations were performed for typical performance but as the duplex-filter baseline performance and quadplexer performance were both simulated it can be assumed that performance difference stays constant under ETC conditions.

Table 6.4.1.4-1: Reported ILs for band 2 + 4 quadplexers

E-UTRA bands	UL IL (dB) vendor 1	DL IL (dB) vendor 1	UL IL (dB) vendor 2	DL IL (dB) vendor 2
2	0.55	0.91	0.46	0.53
4	0.51	0.41	0.51	0.29

Table 6.4.1.4-2: Average UL and DL IL for combining band 2 and band 4

Inter-band CA Configuration	E-UTRA Band	UL IL [dB]	DL IL [dB]
\bar{IL}	2	0.51	0.66
	4	0.51	0.35

6.5 Class A5. Combination except for A1 – A4

<Text will be added.>

Annex A: Change history

Change history							
Date	TSG #	TSG Doc.	CR	Rev	Subject/Comment	Old	New
2012-10	RAN4#64bis	R4-125796			Rel-12 Inter-band Carrier Aggregation Technical Report skeleton	N/A	0.1.0
2012-11	RAN4#65	R4-126715			<p>The following TPs have been implemented:</p> <p>R4-125219, "TP for TR ab.cde (inter-band CA) on IMD study of B38 + B39"</p> <p>R4-125246, "TP for TR36.8XX(Rel-12) : LTE-A Inter-band Carrier Aggregation of Band 1 and Band 8"</p> <p>R4-125401, "TP for CA band combination B3+19"</p> <p>Editorial updates by the rapporteur:</p> <ul style="list-style-type: none"> • Version number changed • Removed the word "non-contiguous" <p>Minor table reference corrections</p>	0.1.0	0.2.0
2013-01	RAN4#66	R4-130546			<p>The following TPs have been implemented:</p> <p>R4-126098, "TP for TR 36.8xx (Inter-Band CA Rel-12): LTE_CA_B3_B26 Core Requirements"</p> <p>R4-126251, "TP for TR36.8xx (Release12): LTE Advanced inter-band Carrier Aggregation of Band 3 and Band 28 (1UL)"</p> <p>R4-126107, "Hammonics and intermodulation products generated by the BS supporting LTE-A CA of Band 2 and Band 4"</p> <p>R4-126407, "Interband CAB2+B4 UE issues"</p> <p>Editorial updates by the rapporteur:</p> <ul style="list-style-type: none"> • TR number updated to 36.851. • Version number changed • Added a table to the Scope clause that lists all Rel-12 inter-band carrier aggregation combinations • LTE_CA_B38_B39 have been removed from the report • LTE_CA_B1_B7 text from TS 36.850 have been included in this report • Added missing reference [4] • Changed the order of subclause 6.1.1, 6.1.2 and 6.1.3 (UID Order) • Minor editorial corrections 	0.2.0	0.3.0
2013-04	RAN4#67	R4-131374			<p>The following TPs have been implemented:</p> <p>R4-130196, "TP TP for TR36.851: CA_1A-26A UE/BS RF aspects"</p> <p>R4-130883, "TP for TR36.851 (Rel-12) : ΔTIB and ΔRIB values of LTE-A Inter-band Carrier Aggregation of Band 3 and Band 19"</p> <p>R4-130033, "TP for TR 36.851: Quadplexer insertion loss data for aggregating band 1"</p> <p>R4-130727, "Additional IL for Band 1 + Band 7 combination"</p> <p>R4-130885, "TP for TR 36.851 on IMD study of inter-band CAB39 + B41"</p> <p>R4-130889 : "TP for TR 36.851 on UE issues for B39+B41"</p> <p>R4-130558, "TP 36.851: modified classes of inter-band combinations (up to 2 UL)"</p> <p>Editorial updates by the rapporteur:</p> <ul style="list-style-type: none"> • Version number changed • Title modified and aligned with TR 36.850 • Table 1-1 updated with 3 new work items • Values in Table 6.3.3.1.3-2 replaced by "[FFS]" <p>Minor editorial corrections</p>	0.3.0	0.4.0

