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Contents

Foreword

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- y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.
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1 Scope

The present document is a technical report for Inter-band Carrier Aggregation under Rel-11 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-11 band combinations in table 1-1.

Table 1-1: Release 11 inter-band carrier aggregation combinations

WI code	WI title	Class
LTE_CA_B3_B7	LTE Advanced Carrier Aggregation of Band 3 and Band 7	A3
LTE_CA_B4_B17	LTE Advanced Carrier Aggregation of Band 4 and Band 17	A2
LTE_CA_B4_B13	LTE Advanced Carrier Aggregation of Band 4 and Band 13	A1
LTE_CA_B4_B12	LTE Advanced Carrier Aggregation of Band 4 and Band 12	A2
LTE_CA_B5_B12	LTE Advanced Carrier Aggregation of Band 5 and Band 12	A3
LTE_CA_B7_B20	LTE Advanced Carrier Aggregation of Band 7 and Band 20	A1
LTE_CA_B2_B17	LTE Advanced Carrier Aggregation of Band 2 and Band 17	A1
LTE_CA_B4_B5	LTE Advanced Carrier Aggregation of Band 4 and Band 5	A1
LTE_CA_B5_B17	LTE Advanced Carrier Aggregation of Band 5 and Band 17	A3
LTE_CA_B3_B20	LTE Advanced Carrier Aggregation of Band 3 and Band 20	A1
LTE_CA_B8_B20	LTE Advanced Carrier Aggregation of Band 8 and Band 20	A3
LTE_CA_B3_B5	LTE Advanced Carrier Aggregation of Band 3 and Band 5	A1
LTE_CA_B4_B7	LTE Advanced Carrier Aggregation of Band 4 and Band 7	A3
LTE_CA_B11_B18	LTE Advanced Carrier Aggregation of Band 11 and Band 18	A5
LTE_CA_B1_B18	LTE Advanced Carrier Aggregation of Band 1 and Band 18	A1
LTE_CA_B1_B19	LTE Advanced Carrier Aggregation of Band 1 and Band 19	A1
LTE_CA_B1_B21	LTE Advanced Carrier Aggregation of Band 1 and Band 21	A5
LTE_CA_B3_B8	LTE Advanced Carrier Aggregation of Band 3 and Band 8	A2

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] RP-110702: "LTE-Advanced Carrier Aggregation of Band 3 and Band 7"

[4] RP-101391: "LTE Advanced Carrier Aggregation of Band 4 and Band 17"

[5] RP-101435: "LTE Advanced Carrier Aggregation of Band 4 and Band 13"

[6] RP-111316: "LTE Advanced Carrier Aggregation of Band 4 and Band 12"

[7] RP-110372: "LTE Advanced Carrier Aggregation of Band 5 and Band 12"

[8] RP-110403: "LTE Advanced Carrier Aggregation of Band 20 and Band 7"

[9] RP-110432: "LTE Advanced Carrier Aggregation of Band 2 and Band 17"

[10] RP-110433: "LTE Advanced Carrier Aggregation of Band 4 and Band 5"

[11] RP-110434: "LTE Advanced Carrier Aggregation of Band 5 and Band 17"

[12] Void.

[13] RP-120899: "LTE Advanced Carrier Aggregation of Band 3 and Band 5"

[14] RP-111358: "LTE inter-band Carrier Aggregation (Band 4 + Band 7) "

[15] RP-111212: "LTE inter-band carrier aggregation for bands 20+3"

[16] RP-111213: "LTE inter-band carrier aggregation for bands 20+8"

[17] R4-120486: "CA Band 1 and 19 specific requirements in TS 36.101", NTT DOCOMO

[18] R4-120490: "CA Band 1 and 21 specific requirements in TS 36.101", NTT DOCOMO

[19] R4-115502: "Way forward on interband insertion loss", Nokia Corporation

[20] RP-120388: "LTE Advanced Carrier Aggregation of Band 3 and Band 8"

[21] R4-123308: "Diplexing and quadplexing between Band 5 and Band 12", Qualcomm Incorporated

[22] 3GPP TS 36.101: "E-UTRA UE radio transmission and reception".

[23] 3GPP TS 36.133: "E-UTRA requirements for support of radio resource management".

[23] R4-126605: "TP to 36.850: additional insertion loss for configuration CA_4A-7A"

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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 Carrier (bandwidth 1.4, 3, 5, 10, 15 or 20 MHz. Max. 5 CCs aggregated => max. 100 MHz)
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-11 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

There are four categories of inter-band CA combinations for UE. For BS, it is typical that different RF modules are used for different bands. Thus, the categories for BS could be simpler than those for UE. The requirements are mainly affected by the BS antenna configurations. Currently, the wide band antenna can support 1.8 GHz to 2.6 GHz frequency range. For the bands lower than 1 GHz, a separate antenna is needed.

For the approved inter-band CA combinations, the low-high band combinations using separate antennas can be treated as one category. The situation for these combinations is similar as current non-CA but co-located BSs. The requirements are covered by current specifications in this scenario. The other category is the band combinations which can use the same antenna. The new issue raised in the antenna sharing scenario is the possible passive intermodulation.

5.2 UE specific

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

E-UTRA carrier aggregation class A1 is designed to operate in the operating bands defined in table 5.2.1-1.

Table 5.2.1-1: Inter-band CA class A1 operating bands

E-UTRA CA Band	E-UTRA Band	Uplink (UL) operating band BS receive / UE transmit F_{UL_low} – F_{UL_high}	Downlink (DL) operating band BS transmit / UE receive F_{DL_low} – F_{DL_high}	Duplex Mode
CA_1-5	1	1920 MHz – 1980 MHz	2110 MHz – 2170 MHz	FDD
	5	824 MHz – 849 MHz	869 MHz – 894MHz	
CA_4-13	4	1710 MHz – 1755 MHz	2110 MHz – 2155 MHz	FDD
	13	777 MHz – 787 MHz	746 MHz – 756 MHz	
CA_7-20	7	2500 MHz – 2570 MHz	2620 MHz – 2690 MHz	FDD
	20	832 MHz – 862 MHz	791 MHz – 821 MHz	
CA_2-[x]	2	1850 MHz – 1910 MHz	1930 MHz – 1990 MHz	FDD
	[x]	N/A – N/A	N/A – N/A	
CA_2-17	2	1850 MHz – 1910 MHz	1930 MHz – 1990 MHz	FDD
	17	704 MHz – 716 MHz	734 MHz – 746 MHz	
CA_3-20	3	1710 MHz – 1785 MHz	1805 MHz – 1880 MHz	FDD
	20	832 MHz – 862 MHz	791 MHz – 821 MHz	

The lower tolerance of P_{CMAX_L} for constituent bands of a class A1 combination is reduced by the amount given in $\Delta T_{IB,c}$ in table 5.2.1-2. This relaxation is applied for each component carrier when operating either in single carrier or carrier aggregation configuration with a single uplink CC.

Table 5.2.1-2: $\Delta T_{IB,c}$ for the UE that supports inter-band CA class A1

Inter-band CA Class A1 Configuration	E-UTRA Band	$\Delta T_{IB,c}$ [dB]
CA_x-y	x	0.3
	y	0.3
NOTE: The values in this table reflect what can be achieved with the present state of the art technology and shall be reconsidered when the state of the art technology progresses.		

The minimum requirement for reference sensitivity for constituent bands of a class A1 combination shall be increased by the amount given in ΔR_{IB} in table 5.2.1-3. This relaxation is applied for each component carrier when operating either in single carrier or carrier aggregation configuration with a single uplink CC.

Table 5.2.1-3: ΔR_{IB} for the UE that supports inter-band CA class A1

Inter-band CA Class A1 Configuration	E-UTRA Band	ΔR_{IB} [dB]
CA_x-y	x	0
	y	0

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

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

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

5.2.5 Class A5. Combination except for A1 – A4

5.3 RRM specific

The RRM requirements will be impacted by the relaxation of the reference sensitivity for UEs supporting inter-band carrier aggregation. table 5.3-1 lists the required modification of the RRM requirements in TS 36.133 [23]. Similar requirements for Rel-10 with only 1 UL carrier will be introduced in Rel-10 of TS 36.133 [23].

Table 5.3-1: Modification of the RRM requirements in TS 36.133 for Inter-Band carrier aggregations.

Section	Requirements	Proposed changes in RRM Requirements
9.1	**E-UTRAN measurements**	
	Table 9.1.2.1-1: RSRP Intra frequency absolute accuracy	For the UE which supports an inter-band carrier aggregation configuration with 1 uplink carrier in one E-UTRA band, the Io level in these tables will be increased by the amount given in $\Delta R_{IB,c}$ for 1 uplink carrier configuration for the applicable E-UTRA bands of the inter-band carrier aggregation. For the UE which supports an inter-band carrier aggregation configuration with 2 uplink carriers, one in each E-UTRA band, the Io level in these tables will be increased by the amount given in $\Delta R_{IB,c}$ for 2 uplink carrier configuration for the applicable E-UTRA bands of the inter-band carrier aggregation.
	Table 9.1.2.2-1: RSRP Intra frequency relative accuracy	
	Table 9.1.2.3-1: RSRP Intra frequency absolute accuracy under time domain measurement resource restriction	
	Table 9.1.2.4-1: RSRP Intra frequency relative accuracy under time domain measurement resource restriction	
	Table 9.1.3.1-1: RSRP Inter frequency absolute accuracy	
	Table 9.1.3.2-1: RSRP Inter frequency relative accuracy	
	Table 9.1.5.1-1: RSRQ Intra frequency absolute accuracy	
	Table 9.1.5.2-1: RSRQ Intra frequency absolute accuracy under time domain measurement resource restriction	
	Table 9.1.6.1-1: RSRQ Inter frequency absolute accuracy	
	Table 9.1.6.2-1: RSRQ Inter frequency relative accuracy	
	Table 9.1.9.1-1: UE Rx – Tx time difference measurement accuracy	
	Table 9.1.10.1-1: RSTD measurement accuracy	
	Table 9.1.10.2-1: RSTD measurement accuracy	
Annex B	**Conditions for RRM requirements applicability for operating bands**	
	Table B.1.1-1 Conditions for measurements of intra-frequency E-UTRAN cells for cell re-selection	For the UE which supports an inter-band carrier aggregation configuration with 1 uplink carrier in one E-UTRA band, the RSRP and SCH_RP levels in these tables will be increased by the amount given in $\Delta R_{IB,c}$ for 1 uplink carrier configuration for the applicable E-UTRA bands of the inter-band carrier aggregation. For the UE which supports an inter-band carrier aggregation configuration with 2 uplink carriers, one in each E-UTRA band, the RSRP and SCH_RP levels in these tables will be increased by the amount given in $\Delta R_{IB,c}$ for 2 uplink carrier configuration for the applicable E-UTRA bands of the inter-band carrier aggregation.
	Table B.2.1-1. E-UTRAN intra-frequency measurements	
	Table B.2.3-1. E-UTRAN inter-frequency measurements	
	Table B.2.4-1. E-UTRAN inter-frequency measurements with autonomous gaps	
	Table B.2.5-1 E-UTRAN OTDOA intra-frequency RSTD measurements	
	Table B.2.7-1. Measurements of the secondary component carrier with deactivated SCell	
	Table B.2.8-1 E-UTRAN intra-frequency measurements under time domain measurement resource Restriction	
	Table B.3.1-1 Intra-frequency absolute RSRP and RSRQ Accuracy Requirements	
	Table B.3.8-1 Intra-frequency relative RSRP accuracy requirements	

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

All inter-band carrier aggregations that belong to Class A1. Low-high band combination without harmonic relation between bands shall follow the requirements defined in this section unless explicitly stated otherwise.

The UE measurement requirements, including OTDOA RSTD, for carrier aggregation specified in subclause 8.3 and 8.4 in TS 36.133 [23] for primary component carrier and secondary component carrier are defined in a band agnostic manner. The measurement accuracy requirements, including OTDOA RSTD, for carrier aggregation, as defined in subclause 9.1.11 and 9.1.12 in TS 36.133 [23] for primary component carrier and secondary component carrier are also in a band agnostic manner.

Since there is no change on reference sensitivity power level (ΔRib= 0 dB) for 2 DL/1 UL for Class A1 CA combinations, there is no need to define additional measurement requirements specific for Class A1 CA combinations for 2 DL/1 UL cases.

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 4 and Band 13 (1 UL)

CA_4-13 is designed to operate in the operating bands defined in table 6.1.1-1.

Table 6.1.1-1: Inter-band CA operating bands

E-UTRA CA Band	E-UTRA Band	Uplink (UL) operating band BS receive / UE transmit F_{UL_low} – F_{UL_high}			Downlink (DL) operating band BS transmit / UE receive F_{DL_low} – F_{DL_high}			Duplex Mode
CA_4-13	4	1710 MHz	–	1755 MHz	2110 MHz	–	2155 MHz	FDD
	13	777 MHz	–	787 MHz	746 MHz	–	756 MHz	

6.1.1.1 List of specific combination issues

6.1.1.1.1 Channel bandwidths per operating band for CA

Supported channel bandwidths per operating band for CA_4-13 are shown in table 6.1.1.1.1-1.

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

CA operating / channel bandwidth								Bandwidth combination set
E-UTRA CA Configuration	E-UTRA Bands	1.4 MHz	3 MHz	5 MHz	10 MHz	15 MHz	20 MHz	
CA_4-13	4			Yes	Yes	Yes	Yes	0
	13				Yes			
	4			Yes	Yes			1
	13				Yes			

6.1.1.1.2 Co-existence studies for CA_4-13 (1 UL)

The 2nd and 3rd order harmonics and IMD products caused in the BS by transmitting of Band 4 and Band 13 DL carriers can be calculated as shown in table 6.1.1.1.2-1 below:

Table 6.1.1.1.2-1: Band 4 and Band 13 DL harmonics and IMD products

BS DL carriers	f1_low	f1_high	f2_low	f2_high
DL frequency (MHz)	746	756	2110	2155
2nd order harmonics frequency range (MHz)	1492	1512	4220	4310
3rd order harmonics frequency range (MHz)	2238	2268	6330	6465
2nd order IMD products	(f2_low – f1_high)	(f2_high – f1_low)	(f2_low + f1_low)	(f2_high + f1_high)
IMD frequency limits (MHz)	1354	1409	2856	2911
3rd 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)	598	663	3464	3564
3rd 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)	3602	3667	4966	5066
3rd order IMD products	(f1_low – f2_high + f2_low)	(f1_high + f2_high – f2_low)	(f2_low – f1_high + f1_low)	(f2_high + f1_high – f1_low)
IMD frequency limits (MHz)	701	801	2100	2165

It can be seen from table 6.1.1.1.2-1 that the 2nd and 3rd harmonics as well as the 2nd IMD products of BS transmitting in Bands 4 and 13 will not fall into the BS receive band of any frequency band currently defined in 3GPP, but the 3rd IMD products supporting CA of Band 4 and Band 13 may fall into the BS receive band of Bands 12, 13, 14, 17, 22, 42 and 43. Note that the calculation in table 6.1.1.1.2-1 assumes the BS is transmitting with the whole 45 MHz DL frequency of Band 4 and the whole 10 MHz DL frequency of Band 13. If the BS is only transmitting an up to 20 MHz DL in Band 4 and a 10 MHz DL in Band 13 as stated in the WIDS, then the 3rd IMD products will not fall into the BS receive band of Bands 12, 13, 14 and 17.

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 22, 42 or 43 receiver would be well below the receiver noise floor eliminating the possibility of receiver desensitization, provided that Bands 4 and 13 BS transmitters do not share the same antenna with Band 22, 42 or 43 BS receiver.

And it is recommended that Bands 4 and 13 BS transmitters should not share the same antenna with Band 22, 42 or 43 BS receiver, unless the antenna path meets very stringent 3rd order PIM specification so that the PIM will not cause Band 22, 42 or 43 BS receiver desensitization.

6.1.1.1.3 $\Delta T_{IB,c}$ and ΔR_{IB} (1 UL)

For the UE which supports CA_4A-13A the $\Delta T_{IB,c}$ is defined for applicable bands in table 6.1.1.1.3-1.

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

Inter-band CA Configuration	E-UTRA Band	$\Delta T_{IB,c}$ [dB]
CA_4A-13A	4	0.3
	13	0.3

For the UE which supports CA_4A-13A the ΔR_{IB} is defined for applicable bands in table 6.1.1.1.3-2.

Table 6.1.1.1.3-2: ΔR_{IB}

Inter-band CA Configuration	E-UTRA Band	ΔR_{IB} [dB]
CA_4A-13A	4	0
	13	0

6.1.2 LTE Advanced Carrier Aggregation of Band 7 and Band 20

CA_7-20 is designed to operate in the operating bands defined in table 6.1.2-1.

Table 6.1.2-1: Inter-band CA operating bands

E-UTRA CA Band	E-UTRA Band	Uplink (UL) operating band			Downlink (DL) operating band			Duplex Mode
		BS receive / UE transmit			BS transmit / UE receive			
		F_{UL_low} – F_{UL_high}			F_{DL_low} – F_{DL_high}			
CA_7-20	7	2500 MHz	–	2570 MHz	2620 MHz	–	2690 MHz	FDD
	20	832 MHz	–	862 MHz	791 MHz	–	821 MHz	

6.1.2.1 List of specific combination issues

6.1.2.1.1 Channel bandwidths per operating band for CA

Supported channel bandwidths per operating band for CA_7-20 are shown in table 6.1.2.1.1-1.

Table 6.1.2.1-1: 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_7A-20A	7				Yes	Yes	Yes
	20			Yes	Yes		

6.1.2.1.2 Co-existence studies for 1 UL/2 DL

Table 6.1.2.1.2-1 gives the intermodulation products for band 20 + band 7 CA with 2 DLs. For the 3-tone IMD analysis the maximum transmission as defined in table 6.1.2.1-1 is considered. Three-tone third order IMD products can fall into the band 20 receiver. 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 6.1.2.1-1 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 22, 38 and 42. 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 22, 38 and 42 receiver should be well below the receiver noise floor eliminating the possibility of receiver desensitization. Provided that the Bands 20 and 7 BS transmitters should not share the same antenna with Band 22, 38 or 42 BS receiver.

Table 6.1.2.1.2-1: 2 DLs B7 + B20 IMD products

BS DL carriers	f1_low	f1_high	f2_low	f2_high
DL frequency (MHz)	791	821	2620	2690
2nd order harmonics frequency range (MHz)	1582 to 1642		5240 to 5380	
3rd order harmonics frequency range (MHz)	2373 to 2463		7860 to 8070	
Two-tone 2nd order IMD products	|f2_low – f1_high|	|f2_high – f1_low|	|f2_low + f1_low|	|f2_high + f1_high|
IMD frequency range (MHz)	1799 to 1899		3411 to 3511	
Two-tone 3rd 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)	978 to 1108		4419 to 4589	
Three-tone 3rd 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)	771 to 841		2610 to 2700	

Table 6.1.2.1.2-2 gives the intermodulation products for band 20 + band 7 CA with 1 UL. None of the intermodulation products fall into the own receive bands. For the case where 3rd order harmonic of band 20 falls into the downlink of band 38, the current TS 36.101 [22] already has requirements covering this case. For the case where 3rd order harmonic of band 20 falls into Band 7 uplink when both carriers are active, since the suppression of harmonic is relative large

(e.g. 80 dB) compared to the power difference between the two active carriers, the impact to high band transmitter can be ignored. Hence no further relaxation is needed.

Table 6.1.2.1.2-2: 1 UL B7 + B20 harmonic products

BS DL carriers	f1_low	f1_high	f2_low	f2_high
UL frequency (MHz)	832	862	2500	2570
2nd order harmonics frequency range (MHz)	1664 to 1724		5000 to 5140	
3rd order harmonics frequency range (MHz)	2496 to 2586		7500 to 7710	

6.1.2.1.3 Co-existence studies for 2 UL/2 DL

Table 6.1.2.1.3-1 gives the intermodulation products for band 20 + band 7 CA with 2 ULs. For the 3-tone IMD analysis the maximum transmission BW as defined in table 6.1.2.1-1 is considered. Two-tone and three-tone third order IMD products can fall into the band 20 receiver. However, these products will not fall into the UE own receive block if the frequency range as defined with the channel bandwidths given in table 6.1.2.1-1 are used for the more detailed IMD calculation.

Considering bands in the same geographical area we observe that the UE distortion falls into the UE receive bands of Band 38 and 42. The magnitude of these possible IMD products have to be further studied with respect to spurious emission limits into these bands.

Table 6.1.2.1.3-1: 2 ULs B7 + B20 IMD products

BS DL carriers	f1_low	f1_high	f2_low	f2_high
DL frequency (MHz)	832	862	2500	2570
Two-tone 2nd order IMD products	|f2_low – f1_high|	|f2_high – f1_low|	|f2_low + f1_low|	|f2_high + f1_high|
IMD frequency range (MHz)	1638 to 1738		3332 to 3432	
Two-tone 3rd 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)	776 to 906		4138 to 4308	
Three-tone 3rd 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)	812 to 882		2490 to 2580	

6.1.2.1.4 $\Delta T_{IB,c}$ and ΔR_{IB} (1 UL/ 2 DL)

For the UE which supports CA_7-20 the $\Delta T_{IB,c}$ is defined for applicable bands in table 6.1.2.1.4-1.

Table 6.1.2.1.4-1: $\Delta T_{IB,c}$

Inter-band CA Configuration	E-UTRA Band	$\Delta T_{IB,c}$ [dB]
CA_7A-20A	7	0.3
	20	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.		

For the UE which supports CA_7-20 the ΔR_{IB} is defined for applicable bands in table 6.1.2.1.4-2.

Table 6.1.2.1.4-2: ΔR_{IB}

Inter-band CA Configuration	E-UTRA Band	ΔR_{IB} [dB]
CA_7A-20A	7	0
	20	0

6.1.3 LTE-Advanced Carrier Aggregation of Band 2 and Band 17 (1 UL)

6.1.3.1 List of specific combination issues

6.1.3.1.1 Channel bandwidths per operating band for CA

6.1.3.1.2 Co-existence studies for CA_2-17

The 2nd and 3rd order harmonics and IMD products caused in the BS by transmitting of Band 2 and Band 17 DL carriers can be calculated as shown in table 6.1.3.1.2-1 below:

Table 6.1.3.1.2-1: Band 2 and Band 17 DL harmonics and IMD products

BS DL carriers	f1_low	f1_high	f2_low	f2_high
DL frequency (MHz)	734	746	1930	1990
2nd harmonics frequency limits (MHz)	1468	1492	3860	3980
3rd harmonics frequency limits (MHz)	2202	2238	5790	5970
2nd order IMD products	(f2_low – f1_high)	(f2_high – f1_low)	(f2_low + f1_low)	(f2_high + f1_high)
IMD frequency limits (MHz)	1184	1256	2664	2736
3rd 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)	438	522	3114	3246
3rd 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)	3398	3482	4594	4726
3rd order IMD products	(f1_low – f2_high + f2_low)	(f1_high + f2_high – f2_low)	(f2_low – f1_high + f1_low)	(f2_high + f1_high – f1_low)
IMD frequency limits (MHz)	674	806	1918	2002
3rd order IMD products (with maximum channel bandwidth)	(f1_low – f2_BWmax)	(f1_high + f2_BWmax)	(f2_low – f1_BWmax)	(f2_high + f1_BWmax)
IMD frequency limits (MHz)	714	766	1920	2000

It can be seen from table 6.1.3.1.2-1 that the 2nd and 3rd harmonics of BS transmitting in Bands 2 and 17 will not fall into the BS receive band of any frequency band currently defined in 3GPP, but the 2nd IMD products may fall into the BS receive band of Band 41, and the 3rd IMD products may fall into the BS receive band of Bands 1, 12, 13, 14, 17, 22, 23, 28, 33, 36, 37, 39, 42 and 44. Note that the calculation in table 6.1.3.1.2-1 (except the last row) assumes the BS is transmitting with the whole 60 MHz DL frequency of Band 2 and the whole 12 MHz DL frequency of Band 17. If the BS is only transmitting an up to 20 MHz DL in Band 2 and a 10 MHz DL in Band 17 as stated in the WIDS, then the 3rd IMD products will not fall into the BS receive band of Bands 13, 14, 23, 33 and 39 as shown in the last row in table 6.1.3.1.2-1.

Note that Bands 1, 28, 33, 39 and 44 are not intended for use in the same geographical area as Bands 2 and 17. Moreover, co-location of Band (2 + 17) transmitter and Band 36 or 37 transceiver implies FDD/TDD co-location on adjacent frequencies which requires the use of certain site-engineering solutions to avoid mutual interference. Furthermore, the 3rd IMD products for Band (2 + 17) DL at 714 – 766 MHz will not fall into the Band 12 or 17 UL if the UL carrier is located out of this frequency range (e.g. locate the 10 MHz UL carrier for Band 12 or 17 at 704 – 714 MHz) or the Band 2 DL bandwidth is limited to not wider than 18 MHz.

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 22, 41 or 42 receiver would be well below the receiver noise floor eliminating the possibility of receiver desensitization, provided that Bands 2 and 17 BS transmitters do not share the same antenna with Band 22, 41 or 42 BS receiver.

Therefore, it is recommended that Bands 2 and 17 BS transmitters should not share the same antenna with Band 22, 41 or 42 BS receiver, or with Band 12 or 17 BS receiver unless the Band 12 or 17 UL carrier is located out of the frequency range at 714 – 766 MHz or the Band 2 DL bandwidth is limited to not wider than 18 MHz, unless the antenna path meets very stringent 3rd order PIM specification so that the PIM will not cause Band 12, 17, 22, 41 or 42 BS receiver desensitization.

6.1.4 LTE-Advanced Carrier Aggregation of Band 4 and Band 5 (1 UL)

6.1.4.1 List of specific combination issues

6.1.4.1.1 Channel bandwidths per operating band for CA

6.1.4.1.2 Co-existence studies for CA_4-5

The 2nd and 3rd order harmonics and IMD products caused in the BS by transmitting of band 4 and band 5 DL carriers can be calculated as shown in table 6.1.4.1.2-1 below:

Table 6.1.4.1.2-1: Band 4 and Band 5 DL harmonics and IMD products

BS DL carriers	f1_low	f1_high	f2_low	f2_high
DL frequency (MHz)	869	894	2110	2155
2nd order harmonics frequency range (MHz)	1738	1788	4220	4310
3rd order harmonics frequency range (MHz)	2607	2682	6330	6465
2nd order IMD products	(f2_low – f1_high)	(f2_high – f1_low)	(f2_low + f1_low)	(f2_high + f1_high)
IMD frequency limits (MHz)	1216	1286	2979	3049
3rd 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)	322	417	3326	3441
3rd 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)	3848	3943	5089	5204
3rd order IMD products	(f1_low – f2_high + f2_low)	(f1_high + f2_high – f2_low)	(f2_low – f1_high + f1_low)	(f2_high + f1_high – f1_low)
IMD frequency limits (MHz)	824	939	2085	2180
3rd order IMD products (with maximum channel bandwidth)	(f1_low – f2_BWmax)	(f1_high + f2_BWmax)	(f2_low – f1_BWmax)	(f2_high + f1_BWmax)
IMD frequency limits (MHz)	849	914	2090	2175

It can be seen from table 6.1.4.1.2-1 that the 2nd and 3rd harmonics of BS transmitting in band 5 may fall into the BS receive band of bands 3, 4, 9, 10, 38 and 41, while the 3rd IMD products caused by BS supporting carrier aggregation of band 4 and band 5 may fall into the BS receive band of bands 5, 6, 8, 18, 19, 20, 22, 26 and 42. Note that the calculation in table 6.1.4.1.2-1 (except the last row) assumes the BS is transmitting with the whole 45 MHz DL frequency of and 4 and the whole 25 MHz DL frequency of and 5. If the BS is only transmitting 10, 15 or 20 MHz DL in band 4 and band 5 as stated in the WIDS, then the 3rd IMD products will not fall into the BS receive band of bands 5, 6, 18, 19 and 26 as shown in the last row in table 6.1.4.1.2-1.

Note that bands 3, 6, 8, 9, 18, 19, 20 and 38 are not intended for use in the same geographical area as bands 4 and 5. 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 harmonics interference generated within the band 4, 10 or 41 receiver would be well below the receiver noise floor eliminating the possibility of receiver desensitization.

On the other hand, it is recommended that bands 4 and 5 BS transmitters should not share the same antenna with band 22 or 42 BS receiver, unless the antenna path meets very stringent 3rd order PIM specification so that the PIM will not cause band 22 or 42 BS receiver desensitization.

6.1.5 LTE inter-band carrier aggregation of Band 3 and Band 20

CA_3-20 inter-band combination is designed to operate in the following 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) operating band BS receive / UE transmit F_{UL_low} – F_{UL_high}	Downlink (DL) operating band BS transmit / UE receive F_{DL_low} – F_{DL_high}	Duplex Mode
CA_3-20	20	832 MHz – 862 MHz	791 MHz – 821 MHz	FDD
	3	1710 MHz – 1785 MHz	1805 MHz – 1880 MHz	

6.1.5.1 List of specific combination issues

6.1.5.1.1 Channel bandwidths per operating band for CA

Supported channel bandwidths per operating band for CA_3-20 are shown in table 6.1.5.1.1-1.

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

E-UTRA band / channel bandwidth							
E-UTRA CA Band	E-UTRA Bands	1.4 MHz	3 MHz	5 MHz	10 MHz	15 MHz	20 MHz
CA_3A-20A	20			Yes	Yes		
	3			Yes	Yes	Yes	Yes

6.1.5.1.2 Co-existence studies for 1 UL/2 DL

Table 6.1.5.1.2-1 gives the intermodulation products for band 20 + band 3 CA with 2 DLs. For the 3-tone IMD analysis the maximum transmission as defined in table 6.1.2.1-1 is considered. Three-tone third order IMD products can fall into the band 20 receiver. 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 6.1.5.1.1-1 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 42 and 43. 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 42 and 43 receiver should be well below the receiver noise floor eliminating the possibility of receiver desensitization. Provided that the Bands 20 and 7 BS transmitters should not share the same antenna with Band 42 or 43 BS receiver.

Table 6.1.5.1.2-1: 2 DLs B3 + B20 IMD products

BS DL carriers	f1_low	f1_high	f2_low	f2_high
DL frequency (MHz)	791	821	1805	1880
2nd order harmonics frequency range (MHz)	1582 to 1642		3610 to 3760	
3rd order harmonics frequency range (MHz)	2373 to 2463		5415 to 5640	
Two-tone 2nd order IMD products	|f2_low – f1_high|	|f2_high – f1_low|	|f2_low + f1_low|	|f2_high + f1_high|
IMD frequency range (MHz)	984 to 1089		2596 to 2701	
Two-tone 3rd 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*f1_high + f2_high)
IMD frequency range (MHz)	163 to 298 3387 to 3522		2789 to 2969 4401 to 4581	
Three-tone 3rd 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)	771 to 841		1795 to 1890	

Table 6.1.2.1.2-2 gives the intermodulation products for band 20 + band 3 CA with 1 UL. None of the intermodulation products fall into the own receive bands. For the case when 3rd order harmonics from band 20 UL impact both B38 (TDD) and B7 UL, TS 36.101 [22] already considers this case, and therefore no further requirements are needed.

Table 6.1.5.1.2-2: 1 UL B3 + B20 harmonic products

UE UL carriers	f1_low	f1_high	f2_low	f2_high
UL frequency (MHz)	832	862	1710	1785
2nd order harmonics frequency range (MHz)	1664 to 1724		3420 to 3570	
3rd order harmonics frequency range (MHz)	2496 to 2586		5130 to 5355	

6.1.5.1.3 Co-existence studies for 2 UL/2 DL

Table 6.1.5.1.3-1 gives the intermodulation products for band 20 + band 3 CA with 2 ULs. For the 3-tone IMD analysis the maximum transmission BW as defined in table 6.1.5.1.1-1 is considered. Three-tone third order IMD products can fall into the band 20 receiver. However, these products will not fall into the UE own receive block if the frequency range as defined with the channel bandwidths given in table 6.1.5.1.1-1 are used for the more detailed IMD calculation.

Considering bands in the same geographical area we observe that the UE distortion could fall into the UE receive bands of Band 7, 8, 38 and 42. The magnitudes of these possible IMD products have to be further studied with respect to spurious emission limits into these bands.

Table 6.1.5.1.3-1: 2 ULs B3 + B20 IMD products

BS DL carriers	f1_low	f1_high	f2_low	f2_high
DL frequency (MHz)	832	862	1710	1785
Two-tone 2nd order IMD products	|f2_low – f1_high|	|f2_high – f1_low|	|f2_low + f1_low|	|f2_high + f1_high|
IMD frequency range (MHz)	848 to 953		2542 to 2647	
Two-tone 3rd 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*f1_high + f2_high)
IMD frequency range (MHz)	14 to 121 3374 to 3509		2558 to 2738 4252 to 4432	
Three-tone 3rd 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)	812 to 882		1700 to 1795	

6.1.5.1.4 ΔT_{IB} and ΔR_{IB} values (1 UL/2 DL)

For 2 DL and 1 UL the $\Delta T_{IB,c}$ and ΔR_{IB} values are given in the tables below:

Table 6.1.5.1.4-1: $\Delta T_{IB,c}$

Inter-band CA Configuration	E-UTRA Band	$\Delta T_{IB,c}$ [dB]
CA_3A-20A	20	0.3
	3	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 6.1.5.1.4-2: ΔR_{IB}

Inter-band CA Configuration	E-UTRA Band	ΔR_{IB} [dB]
CA_3A-20A	20	0
	3	0

6.1.6 LTE Advanced Carrier Aggregation of Band 3 and Band 5 (1 UL)

Table 6.1.6-1: 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)	
		FUL_low – FUL_high		FUL_low – FUL_high		
CA_3-5	3	1710 MHz – 1785 MHz	10, 15, 20 (note 1)	1805 MHz – 1880 MHz	10, 15, 20	FDD
	5	824 MHz – 849 MHz	10 (note 1)	869 MHz – 894 MHz	10	
NOTE 1: Only one uplink component carrier is to be supported in any of the two frequency bands at any time.						

6.1.6.1 List of specific combination issues

6.1.6.1.1 Channel bandwidths per operating band for CA

Table 6.1.6.1.1-1: Supported E-UTRA bandwidths per CA configuration for inter-band CA

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

6.1.6.1.2 Co-existence studies for CA_3-5

As shown in table below, the harmonic frequencies of band 3 and band 5 in UL are away from the receive bands of interest in the DL and we can conclude that there is no issue on UL harmonic interference.

Table 6.1.6.1.2-1: Impact of UL Harmonic Interference

					2nd Harmonic		3rd Harmonic	
Band	UL Low Band Edge	UL High Band Edge	DL Low Band Edge	DL High Band Edge	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
5	824	849	869	894	1648	1698	2472	2547

6.1.6.1.2.1 Co-existence studies for 1 UL/2 DL

The 2nd and 3rd order harmonics and IMD products caused in the BS by transmitting of Band 3 and Band 5 DL carriers can be calculated as shown in table 6.1.6.1.2.1-1 below:

Table 6.1.6.1.2.1-1: Band 3 and Band 5 DL harmonics and IMD products

BS DL carriers	f1_low	f1_high	f2_low	f2_high
DL frequency (MHz)	869	894	1805	1880
2nd order harmonics frequency range (MHz)	1738	1788	3610	3760
3rd order harmonics frequency range (MHz)	2607	2682	5415	5640
2nd order IMD products	(f2_low – f1_high)	(f2_high – f1_low)	(f2_low + f1_low)	(f2_high + f1_high)
IMD frequency limits (MHz)	911	1011	2674	2774
3rd 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)	17	142	2716	2891
3rd 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)	3543	3668	4479	4654
3rd order IMD products	(f1_low – f2_high + f2_low)	(f1_high + f2_high – f2_low)	(f2_low – f1_high + f1_low)	(f2_high + f1_high – f1_low)
IMD frequency limits (MHz)	794	969	1780	1905
3rd order IMD products (with maximum channel bandwidth)	(f1_low – f2_BWmax)	(f1_high + f2_BWmax)	(f2_low – f1_BWmax)	(f2_high + f1_BWmax)
IMD frequency limits (MHz)	849	914	1795	1890

It can be seen from table 6.1.6.1.2.1-1 that the 2nd harmonics of BS transmitting in Band 3 and Band 5 may fall into the BS receive band of Bands 3, 4, 9, 10 and 43, and the 3rd harmonics of BS transmitting in Band 5 may fall into the BS receive band of Bands 38 and 41, while the 2nd IMD products of BS supporting CA of Band 3 and Band 5 may fall into the BS receive band of Bands 8 and 41, and the 3rd IMD products may fall into the BS receive band of Bands 2, 3, 5, 6, 8, 9, 14, 18, 19, 20, 25, 26, 27, 33, 35, 39, 42, 43 and 44. Note that the calculation in table 6.1.6.1.2.1-1 (except the last row) assumes the BS is transmitting with the whole 75 MHz DL frequency of Band 3 and the whole 25 MHz DL frequency of Band 5. If the BS is only transmitting an up to 20 MHz DL in Band 3 and an up to 10 MHz DL in Band 5 as stated in the WIDS, then the 3rd IMD products will not fall into the BS receive band of Band 3, 5, 6, 9, 14, 18, 19, 26, 27, 33 or 44. Moreover, only the highest 10 MHz frequency spectrum in Band 8 (905 – 915 MHz for UL and 950 – 960 MHz for DL) is allocated for mobile services in South Korea, thus the 2nd IMD products may only fall into the BS receive band of Band 8 frequency spectrum used in South Korea (905 – 915 MHz) under the transmit configurations shown in table 6.1.6.1.2.1-2 below.

Table 6.1.6.1.2.1-2: Band (3 + 5) BS transmit configurations with 2nd IMD within 905 – 915 MHz

Band 3 DL channel bandwidth (MHz)	Band 5 DL channel bandwidth (MHz)	Lower edge of Band 3 DL frequency block minus higher edge of Band 5 DL frequency block (MHz)	IMD frequency limits (MHz)
5, 10, 15 or 20	5 or 10	≤ 915	911 – 915

And the 3rd IMD products may only fall into the BS receive band of Band 8 frequency spectrum used in South Korea (905 – 915 MHz) under the transmit configurations (with a 15 or 20 MHz DL in Band 3) shown in table 6.1.6.1.2.1-3 below.

Table 6.1.6.1.2.1-3: Band (3 + 5) BS transmit configurations with 3rd IMD within 905 – 915 MHz

Band 5 DL channel bandwidth (MHz)	Band 5 DL frequency block (MHz)	Band 3 DL channel bandwidth (MHz)	IMD frequency limits (MHz)
5	889 – 894	15	874 – 909
5	889 – 894	20	869 – 914
10	884 – 894	15	869 – 909
10	884 – 894	20	864 – 914
5	884 – 889	20	864 – 909
10	879 – 889	20	859 – 909

Note that Bands 2, 4, 6, 9, 10, 14, 18, 19, 20, 25, 27, 33, 35, 38, 39, 41, 42, 43 and 44 are not intended for use in the same geographical area as Bands 3 and 5. Moreover, the 3rd IMD products will not fall into the BS receive band of Band 3, 5 or 26 if the BS is only transmitting an up to 20 MHz DL in Band 3 and an up to 10 MHz DL in Band 5, Consequently, the focus here will be on the harmonics and IMD products falling into Band 8 (3rd IMD products at 849 – 914 MHz). As shown above, the 2nd and 3rd order IMD products caused by mixing of Bands 3 and 5 DL carriers may

fall within Band 8 UL used in South Korea if certain BS transmit configurations are used, and hence BS receiver desensitization may be an issue.

Therefore, it is recommended that Bands 3 and 5 BS transmitters should not share the same antenna with Band 8 BS receiver for the affected frequency ranges if the aforementioned BS transmit configurations are used, unless the antenna path meets very stringent 2nd and 3rd order PIM specification so that the PIM will not cause Band 8 BS receiver desensitization.

6.1.6.1.3 ΔT_{IB} 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.

Table 6.1.6.1.3-1: $\Delta T_{IB,c}$

Inter-band CA Configuration	E-UTRA Band	$\Delta T_{IB,c}$ [dB]
CA_3A-5A	3	0.3 1)
	5	0.3 1)
NOTE 1: 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 6.1.6.1.3-2: ΔR_{IB}

Inter-band CA Configuration	E-UTRA Band	ΔR_{IB} [dB]
CA_3A-5A	3	0
	5	0

6.1.7 LTE Advanced Carrier Aggregation of Band 1 and Band 18

CA_1-18 is designed to operate in the operating bands defined in table 6.1.7-1.

Table 6.1.7-1: 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_1-18	1	1920 MHz – 1980 MHz	5, 10, 15, 20	2110 MHz – 2170 MHz	5, 10, 15, 20	FDD
	18	815 MHz – 830 MHz	5, 10, 15	860 MHz – 875 MHz	5, 10, 15	

6.1.7.1 List of specific combination issues

6.1.7.1.1 Channel bandwidths per operating band for CA

Table 6.1.7.1.1-1: 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-18A	1			Yes	Yes	Yes	Yes
	18			Yes	Yes	Yes	

6.1.7.1.2 Co-existence studies for CA 1-18

Although Band 1 and Band 18 are a High-Low band combination, the harmonic frequencies do not fall into the frequency ranges of both bands as observed in table 6.1.7.1.2-1. Therefore we can conclude that there is no issue on harmonic interference.

Table 6.1.7.1.2-1: Impact of UL/DL Harmonic Interference

					2nd Harmonic		3rd Harmonic		2nd Harmonic		3rd Harmonic	
Band	UL Low Band Edge	UL High Band Edge	DL Low Band Edge	DL High Band Edge	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
18	815	830	860	875	1630	1660	2445	2490	1720	1750	2580	2625

Table 6.1.7.1.2-2 and 6.1.7.1.2-3 gives the frequency range of the third and fifth order intermodulation product when two simultaneous ULs/DLs are active in Band 1 and band 18. It can be seen that the intermodulation products are not falling within the two inter-bands and therefore no further relaxation is needed.

Table 6.1.7.1.2-2: Third order and fifth order intermodulation products (UL)

Band	UL Low band edge	UL High band edge	UL 3rd order products	UL 5th order products
1	1920 MHz	1980 MHz	N/A	N/A
18	815 MHz	830 MHz	3010 – 3145 MHz	4100 – 4310 MHz

Table 6.1.7.1.2-3: Third order and fifth order intermodulation products (UL)

Band	UL Low band edge	UL High band edge	UL 3rd order products	UL 5th order products
1	2110 MHz	2170 MHz	N/A	N/A
18	830 MHz	875 MHz	3345 – 3480 MHz	4580 – 4790 MHz

6.1.7.1.3 ΔT_{IB} and ΔR_{IB} values

Following relaxations are allowed for the UE which supports inter-band carrier aggregation of Band 1 and Band 18. Values are applicable both for 1 UL and 2 UL.

Table 6.1.7.1.3-1: $\Delta T_{IB,c}$

Inter-band CA Configuration	E-UTRA Band	$\Delta T_{IB,c}$ [dB]
CA_1A-18A	1	0.3
	18	0.3

Table 6.1.7.1.3-2: ΔR_{IB}

Inter-band CA Configuration	E-UTRA Band	ΔR_{IB} [dB]
CA_1A-18A	1	0
	18	0

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

Table 6.1.8-1: Inter-band CA

E-UTRA CA Band	E-UTRA Band	Uplink (UL) band	Downlink (DL) band	Duplex Mode
		BS receive / UE transmit[1]	BS transmit / UE receive	
		F_{UL_low} – F_{UL_high}	F_{DL_low} – F_{DL_high}	
CA_1-19	1	1920 MHz – 1980 MHz	2110 MHz – 2170 MHz	FDD
	19	830 MHz – 845MHz	875 MHz – 890 MHz	
NOTE 1: A single uplink component carrier of either Band 1 or Band 19 shall be used at any time.				

6.1.8.1 List of specific combination issues

6.1.8.1.1 Channel bandwidths per operating band for CA

Table 6.1.8.1.1-1: Supported E-UTRA bandwidths per CA configuration for inter-band CA

E-UTRA CA Configuration	Supported E-UTRA bandwidths per CA configuration for inter-band CA					
CA_1A-19A	**E-UTRA Bands**	Band 1				
	Band 19	**CBW**	**5 MHz**	**10 MHz**	**15 MHz**	**20 MHz**
		5 MHz	Yes	Yes	Yes	
		10 MHz	Yes	Yes	Yes	
		15 MHz			Yes	Yes

6.1.8.1.2 Co-existence studies for CA_1-19

As Band 1 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 6.1.8.1.2-1) and therefore we can conclude that there is no issue on harmonic interference.

Table 6.1.8.1.2-1: Impact of UL/DL Harmonic Interference

					2nd Harmonic		3rd Harmonic		2nd Harmonic		3rd Harmonic	
Band	**UL Low Band Edge**	**UL High Band Edge**	**DL Low Band Edge**	**DL High Band Edge**	**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
19	830	845	875	890	1660	1690	2490	2535	1750	1780	2625	2670

6.1.8.1.3 ΔT_{IB}

CA 1A-19A belongs to Class A1. Therefore, according to [17], the followings can be derived.

Table 6.1.8.1.3-1: $\Delta T_{IB,c}$

Inter-band CA Configuration	E-UTRA Band	$\Delta T_{IB,c}$ [dB]
CA_1A-19A	1	0.3
	19	0.3

6.1.8.1.4 ΔR_{IB}

CA 1A-19A belongs to Class A1. Therefore, according to [17], the followings can be derived.

Table 6.1.8.1.4-1: ΔR_{IB}

Inter-band CA Configuration	E-UTRA Band	ΔR_{IB} [dB]
CA_1A-19A	1	0
	19	0

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

6.2.1 LTE Advanced Carrier Aggregation of Band 4 and Band 17 (1 UL)

6.2.1.1 List of specific combination issues

6.2.1.1.1 Channel bandwidths per operating band for CA

6.2.1.1.2 Co-existence studies for CA_4-17 (1 UL)

The 2nd and 3rd order harmonics and IMD products caused in the BS by transmitting of Band 4 and Band 17 DL carriers can be calculated as shown in table 6.2.1.1.2-1 below:

Table 6.2.1.1.2-1: Band 4 and Band 17 DL harmonics and IMD products

BS DL carriers	f1_low	f1_high	f2_low	f2_high
DL frequency (MHz)	734	746	2110	2155
2nd order harmonics frequency range (MHz)	1468	1492	4220	4310
3rd order harmonics frequency range (MHz)	2202	2238	6330	6465
2nd order IMD products	(f2_low – f1_high)	(f2_high – f1_low)	(f2_low + f1_low)	(f2_high + f1_high)
IMD frequency limits (MHz)	1364	1421	2844	2901
3rd 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)	618	687	3474	3576
3rd 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)	3578	3647	4954	5056
3rd order IMD products	(f1_low – f2_high + f2_low)	(f1_high + f2_high – f2_low)	(f2_low – f1_high + f1_low)	(f2_high + f1_high – f1_low)
IMD frequency limits (MHz)	689	791	2098	2167

It can be seen from table 6.2.1.1.2-1 that the 2nd and 3rd harmonics as well as the 2nd IMD products of BS transmitting in Bands 4 and 17 will not fall into the BS receive band of any frequency band currently defined in 3GPP, but the 3rd IMD products supporting CA of Band 4 and Band 17 may fall into the BS receive band of Bands 12, 13, 14, 17, 22, 42 and 43. Note that the calculation in table 6.2.1.1.2-1 assumes the BS is transmitting with the whole 45 MHz DL frequency of Band 4 and the whole 10 MHz DL frequency of Band 17. If the BS is only transmitting an up to 10 MHz DL in Band 4 and a 10 MHz DL in Band 17 as stated in the WIDS, then the 3rd IMD products will not fall into the BS receive band of Bands 12, 13, 14 and 17.

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 22, 42 or 43 receiver would be well below the receiver noise floor eliminating the possibility of receiver desensitization, provided that Bands 4 and 17 BS transmitters do not share the same antenna with Band 22, 42 or 43 BS receiver.

And it is recommended that Bands 4 and 17 BS transmitters should not share the same antenna with Band 22, 42 or 43 BS receiver, unless the antenna path meets very stringent 3rd order PIM specification so that the PIM will not cause Band 22, 42 or 43 BS receiver desensitization.

6.2.1.1.3 Maximum Sensitivity Degradation (MSD) for Band 4

The Band 4 + Band 17 CA configuration has been identified as an A2 combination where the 3rd harmonic from a UE uplink transmission in Band 17 may land within the downlink of Band 4. Because of the significant overlap of 3rd harmonic interference, the maximum sensitivity degradation (MSD) is defined for Band 4 when transmitting in Band 17.

6.2.1.1.3.1 Conditions for MSD

The following conditions are defined for the MSD for Band 4 + Band 17 with the principle that the 3rd harmonic interference should be fully overlapped and entirely contained within the downlink RB's being received in Band 4.

- For the Band 17 uplink, the channel can be placed anywhere in the band. While it may not be true for other class A2 band combinations, for the Band 4 + Band 17 combination, there is always full overlap of the 3rd harmonic of the uplink into the downlink. The Band 17 downlink is placed according to the default Band 17 Rx-Tx separation of 30 MHz.

- For the Band 4 downlink, the channel should be placed at 3x the Band 17 uplink frequency. The Band 4 uplink is placed according to the default Band 4 Rx-Tx separation of 400 MHz.

- As for all reference sensitivity/MSD tests, the downlink should be fully allocated for Band 4 downlink and for Band 17 downlink.

- The Band 17 uplink size should be 1/3 of the Band 4 downlink size; that is, for 10 MHz CBW in Band 4, the Band 17 uplink should be 16 RB's and for 5 MHz CBW in Band 4, the Band 17 uplink should be 8 RB's.

- The uplink allocation in Band 17 can be placed anywhere in the channel since there is always full overlap no matter where it is placed. We therefore propose to place the Band 17 uplink in the highest portion of the channel as close as possible to the Band 17 downlink to represent the worst case.

Examples are provided below:

Table 6.2.1.1.3.1-1: Example MSD configuration of Band 4 and Band 17 channels

Band 17 UL and DL			Band 4 DL	
Bandwidth	Frequency of Uplink	Frequency of Downlink	Bandwidth	Frequency of Downlink
5	706.5	736.5	5	2124
5	707.5	737.5	5	2127
5	712.5	742.5	5	2142
5	713.5	743.5	5	2145
5	706.5	736.5	10	2122
5	707.5	737.5	10	2125
5	712.5	742.5	10	2140
5	713.5	743.5	10	2143
10	709	739	5	2131.6
10	711	741	5	2137.6
10	709	739	10	2129.4
10	711	741	10	2135.4

Table 6.2.1.1.3.1-2: Uplink configuration for MSD for CA_4-17

CA configuration	E-UTRA Band	CC combination								Duplex Mode
		25RB+25RB		25RB+50RB		50RB+25RB		50RB+50RB		
CA_4A-17A	4	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	FDD
	17	n/a	8	n/a	8	n/a	16	n/a	16	

NOTE 1: The CC combination is denoted by the N_{RB} of each component carrier in the CA configuration. For the CA configuration CA_XA-YA, the N_{RB} of the component carriers in band X and band Y are listed in order with CC combination $N_{RB}(X) + N_{RB}(Y)$.
NOTE 2: The transmitted power of the PCC shall be set to P_{UMAX} as defined in subclause 6.2.5.

6.2.1.1.3.2 Reference architecture

To determine the value of MSD, a reference architecture is adopted where a harmonic trip filter is used on the Band 17 RF path value to suppress the 3rd harmonic interference term at the output of the duplexer. The block diagram is shown below

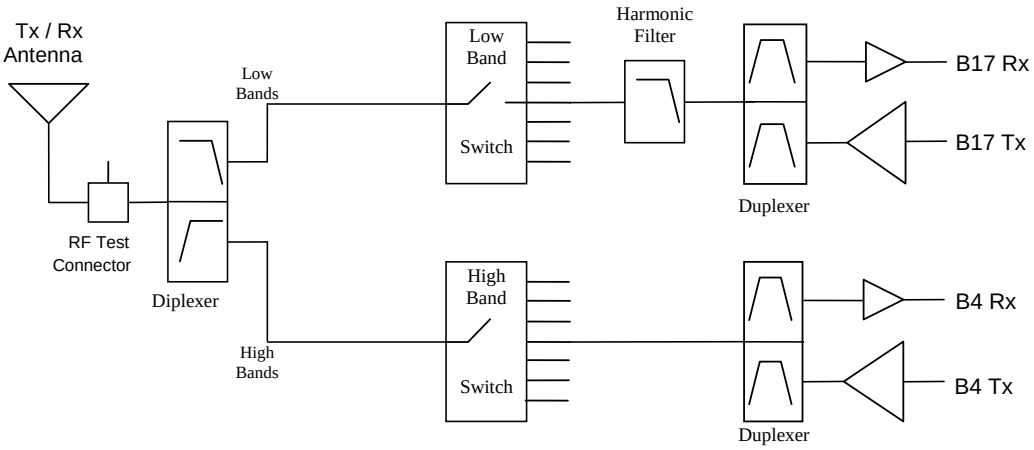

Figure 6.2.1.1.3.2-1: Reference architecture for Band 4 + Band 17

6.2.1.1.3.3 Analysis of MSD

The analysis is summarized below assuming high linearity component selection and the implementation of a diplexer at the antenna port.

Table 6.2.1.1.3.3-1: Harmonic interference calculation

	Primary		Diversity	
Parameter	**Value**	**H3 level**	**Value**	**H3 level**
B17 Tx	27.5		27.5	
B17 PA H3	-50	-22.5	-50	-22.5
B17 duplexer	40	-62.5	40	-62.5
Harmonic filter	30.5	-93.0	30.5	-93.0
LB switch	-96.5	-91.4	-96.5	-91.4
Diplexer	15	-106.4	15	-106.4
Antenna isolation			10	-116.4
HB switch attenuation	0.7	-107.1	0.7	-117.1
HB switch H3	-126	-107.0	-111.9	-110.8
B4 duplexer attenuation	1.6	-108.6	1.6	-112.4
B4 duplexer H3	-126	-108.6	-111.9	-109.1
B17 PA to B4 LNA isolation	80	-102.5	80	-102.5
Single chip DA to LNA	-100	-100.0	-100	-100.0
Composite		-97.7		-97.7

The analysis also includes an estimate of achievable isolation on the PCB as well as on the chip for single-chip designs. The composite additional noise seen at the input to the Band 4 LNA is estimated to be -97.7 dBm. Evaluating the impact of this additional interference to reference sensitivity and assuming that the interference impinging upon the primary and diversity receivers is correlated much in the same way a blocker is tested, we conclude that the reference sensitivity is degraded by 10.2 dB for the 5 MHz channel bandwidth case, and by 7.6 dB for the 10 MHz channel

bandwidth case. However, in previous agreement, the diplexer insertion loss should not be included in reference sensitivity relaxation so the MSD becomes 9.9 dB and 7.3 dB for 5 MHz and 10 MHz channel bandwidths, respectively, which we round to 10 dB and 7.5 dB.

Table 6.2.1.1.3.3-2: Proposed MSD specification for CA_4-17 configuration

CA configuration	E-UTRA Band	CC combination				Duplex Mode
		25RB+25RB	25RB+50RB	50RB+25RB	50RB+50RB	
CA_4A-17A	4	-90	-90	-89.5	-89.5	FDD
	17	n/a	n/a	n/a	n/a	
NOTE 1: The CC combination is denoted by the N_{RB} of each component carrier in the CA configuration. For the CA configuration CA_XA-YA, the N_{RB} of the component carriers in band X and band Y are listed in order with CC combination $N_{RB}(X) + N_{RB}(Y)$. NOTE 2: The transmitter in the lower frequency band shall be set to P_{UMAX} as defined in subclause 6.2.5.						

Because the reference architecture and the analysis assume the use of a harmonic filter in the uplink path of Band 17, an insertion loss in addition to that of the diplexer must be taken into consideration. As noted previously, in this architecture, the filter insertion loss only affects Band 17 including both uplink and downlink. However, as with the diplexer, the insertion loss is present even when the device is operating in single carrier configuration since it forms a part of the signal path. The insertion loss of the filter has been reported by the filter vendor to be 0.5 dB. It has been previously agreed for class A1 configurations that the insertion loss of the diplexer is to be accounted for partially by implementation margin and partially by relaxations to maximum output power and reference sensitivity. We apply the 0.5 dB filter insertion loss on top of these relaxations for this band combination.

Table 6.2.1.1.3.3-3: $\Delta T_{IB,c}$

Inter-band CA Configuration	E-UTRA Band	$\Delta T_{IB,c}$ [dB]
CA_4A-17A	4	0.3
	17	0.8

Table 6.2.1.1.3.3-4: $\Delta R_{IB,c}$

Inter-band CA Configuration	E-UTRA Band	$\Delta R_{IB,c}$ [dB]
CA_4A-17A	4	0
	17	0.5

6.2.1.1.4 Maximum sensitivity reduction for band 4

When band 4 DL is operated simultaneously with band 17 UL there is a potential self interference situation as the third harmonic of band 17 UL will be on the same frequency range as the band 4 DL. It is agreed that 3GPP will set the limit for this interference by specifying maximum sensitivity degradation (MSD) in TS 36.101 [22].

For the MSD study we have assumed UE architecture in figure 6.2.1.1.4-1.

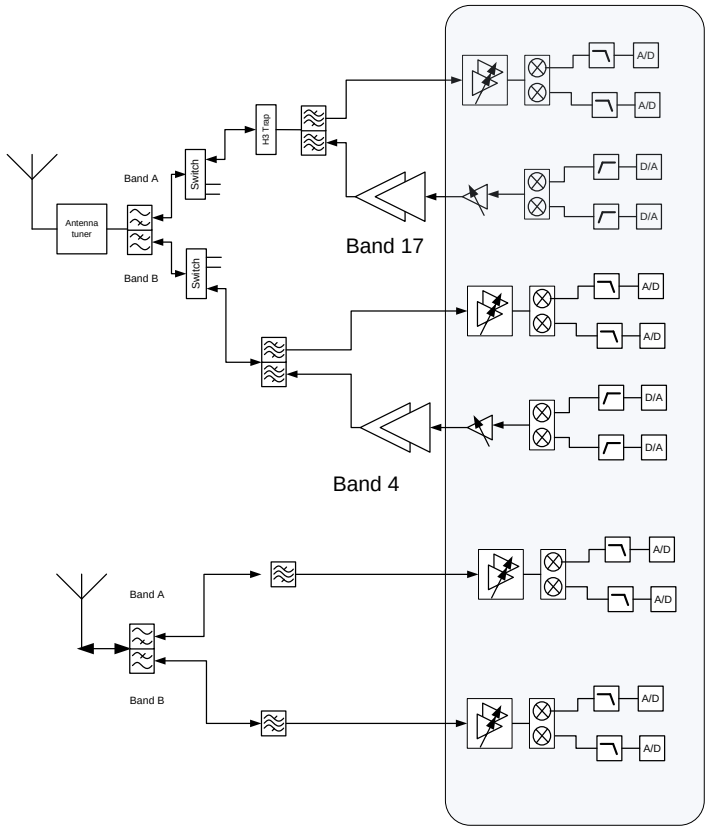

Figure 6.2.1.1.4-1: UE architecture for band combination 17+4

MSD for LTE channel bandwidths of 5 and 10 MHz are calculated with typical component specification values assuming the usage of active antenna tuning or switching elements. Results are presented in table 6.2.1.1.4-1.

Table 6.2.1.1.4-1: MSD for LTE channel bandwidths of 5 and 10 MHz

Ch BW (MHz)	10		5	
NF (dB)	9		9	
RX noise floor (dBm)	-95,5		-98,5	
Antenna Isolation (dB)	10,0		10,0	
	Harmonic level typical component values		Harmonic level typical component values	
PA output (dBm)	-34		-34	
Duplexer attenuation (dB)	-42		-42	
Duplexer contribution (dBc)	-93		-93	
Duplexer output (dBm)	-66,5		-66,5	
Trap attenuation (dBm)	-20		-20	
Switch contribuiton (dBc)	-109		-109	
Switch output (dBm)	-83,2		-83,2	
Diplexer attenuation (dB)	-20		-20	
Tuner contribution (dBc)	-106		-106	
	Main path typical	Div path typical	Main path typical	Div path typical
Antenna port (dBm)	-83,0	-93,0	-83,0	-93,0
PWB coupling (dB) = -90	-83,0	-93,0	-83,0	-93,0
PWB coupling (dB) = -75	-82,9	-92,9	-82,9	-92,9
PWB coupling (dB) = -60	-82,6	-90,4	-82,6	-90,4
	Typical Desense, main	Typical desense, div	Typical Desense, main	Typical desense, div
No coupling	12,7	4,4	15,6	6,6
PWB coupling (dB) = -90	12,7	4,4	15,6	6,6
PWB coupling (dB) = -75	12,7	4,5	15,6	6,7
PWB coupling (dB) = -60	13,0	6,2	15,9	8,7
	Total Desense (typ)		Total Desense (typ)	
No coupling	6,8		9,1	
PWB coupling (dB) = -90	6,8		9,1	
PWB coupling (dB) = -75	6,9		9,2	
PWB coupling (dB) = -60	8,4		10,9	

Based on the calculations presented in table 6.2.1.1.4-1 the MSD shall be specified in following manner into TS 36.101 [22].

Table 6.2.1.1.4-2: MSD

Inter-band CA Configuration	E-UTRA Band	$\Delta T_{IB,c}$ [dB]
CA_4A-17A	4	0.3
	17	0.8

To enable the harmonic suppression used in calculations presented in table 6.2.1.1.4-1 a usage of harmonic rejection filter is assumed. To enable this an allowance is given to maximum output power of band 17 by defining the ΔTib,c = 0.8 dB. This value contains 0.3 dB for the diplexer as agreed for Hi-low combinations without harmonic relation and 0.5 dB for the insertion loss of harmonic trap.

Table 6.2.1.1.4-3: ΔTIB,c

Inter-band CA Configuration	E-UTRA Band	$\Delta T_{IB,c}$ [dB]
CA_4A-17A	4	0
	17	0.5

Similarly to enable the harmonic suppression filter an allowance is given to REFSENS of band 17 by defining the ΔRib,c = 0.5 dB.

Table 6.2.1.1.4-4: ΔRIB,c

Inter-band CA Configuration	E-UTRA Band	$\Delta R_{IB,c}$ [dB]
CA_4A-17A	4	0
	17	0.5

6.2.2 LTE-Advanced Carrier Aggregation of Band 4 and Band 12 (1 UL)

Table 6.2.2-1: Inter-band CA

E-UTRA CA Band	E-UTRA Band	Uplink (UL) operating band BS receive / UE transmit F_{UL_low} – F_{UL_high}			Downlink (DL) operating band BS transmit / UE receive F_{DL_low} – F_{DL_high}			Duplex Mode
CA_4-12	4	1710 MHz	–	1755 MHz	2110 MHz	–	2155 MHz	FDD
	12	699 MHz	–	716 MHz	729 MHz	–	746 MHz	

6.2.2.1 List of specific combination issues

6.2.2.1.1 Channel bandwidths per operating band for CA

Table 6.2.2.1.1-1: 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_4A-12A	4	Yes	Yes	Yes	Yes		
	12			Yes	Yes		

6.2.2.1.2 Co-existence studies for CA_4-12

The combination of band 4 and band 12 has harmonic frequencies that are far removed from the component receive and transmit frequencies, in the UL and in the DL of the CA combination, as shown in table 6.2.2.1.2-1, with the exception of one 3rd order harmonic falling in the BC4 downlink band. 3rd order harmonics are expected to be significantly attenuated, but further study will be required to confirm that there is no detrimental impact.

Table 6.2.2.1.2-1: Impact of UL/DL Harmonic Interference

					2nd Harmonic		3rd Harmonic		2nd Harmonic		3rd Harmonic	
Band	UL Low Band Edge	UL High Band Edge	DL Low Band Edge	DL High Band Edge	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
4	1710	1755	2110	2155	3420	3510	5130	5265	4220	4310	6330	6465
12	699	716	729	746	1398	1432	2097	2148	1458	1492	2187	2238

Table 6.2.1.1.2-2 gives the frequency range of the second and third order inter-modulation products when two simultaneous ULs are active in band 4 and band 12. It can be seen that the inter-modulation products are not falling within the two bands and therefore no further relaxation is needed.

Table 6.2.2.1.2-2: Second-order and third-order inter-modulation products

Band	UL low band edge	UL high band edge	DL low band edge	DL high band edge	UL 2nd order products	UL 3rd order products
4	1710 MHz	1755 MHz	2110 MHz	2155 MHz	994 – 1056 MHz 2409 – 2471 MHz	2704 – 2811 MHz 3108 – 3187 MHz 4119 – 4226 MHz
12	699 MHz	716 MHz	729 MHz	746 MHz		

6.2.2.1.2.1 Co-existence studies for 1 UL/2 DL

The 2nd and 3rd order harmonics and IMD products caused in the BS by transmitting of Band 4 and Band 12 DL carriers can be calculated as shown in table 6.2.2.1.2.1-1 below:

Table 6.2.2.1.2.1-1: Band 4 and Band 12 DL harmonics and IMD products

BS DL carriers	f1_low	f1_high	f2_low	f2_high
DL frequency (MHz)	729	746	2110	2155
2nd harmonics frequency limits (MHz)	1458	1492	4220	4310
3rd harmonics frequency limits (MHz)	2187	2238	6330	6465
2nd order IMD products	(f2_low – f1_high)	(f2_high – f1_low)	(f2_low + f1_low)	(f2_high + f1_high)
IMD frequency limits (MHz)	1364	1426	2839	22901
3rd 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)	618	697	3474	3581
3rd 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)	3568	3647	4949	5056
3rd order IMD products	(f1_low – f2_high + f2_low)	(f1_high + f2_high – f2_low)	(f2_low – f1_high + f1_low)	(f2_high + f1_high – f1_low)
IMD frequency limits (MHz)	684	791	2093	2172
3rd order IMD products (with maximum channel bandwidth)	(f1_low – f2_BWmax)	(f1_high + f2_BWmax)	(f2_low – f1_BWmax)	(f2_high + f1_BWmax)
IMD frequency limits (MHz)	719	756	2100	2165

It can be seen from table 6.2.2.1.2.1-1 that the 2nd harmonics of BS transmitting in Band 12 may fall into the BS receive band of Band 21, while the 3rd IMD products of BS supporting carrier aggregation of Band 4 and Band 12 may fall into the BS receive band of Bands 12, 13, 14, 17, 22, 28, 42, 43 and 44. Note that the calculation in table 6.2.2.1.2.1-1 (except the last row) assumes the BS is transmitting with the whole 45 MHz DL frequency of Band 4 and the whole 17 MHz DL frequency of Band 12. If the BS is only transmitting up to 10 MHz DL in Band 4 and Band 12 as stated in the WIDS, then the 3rd IMD products will not fall into the BS receive band of Bands 12, 13, 14 and 17 as shown in the last row in table 6.2.2.1.2.1-1.

Note that Bands 21, 28 and 44 are not intended for use in the same geographical area as Bands 4 and 12. Moreover, 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 22, 42 or 43 receiver would be well below the receiver noise floor eliminating the possibility of receiver desensitization, provided that Bands 4 and 12 BS transmitters do not share the same antenna with Band 22, 42 or 43 BS receiver.

Therefore, it is recommended that Bands 4 and 12 BS transmitters should not share the same antenna with Band 22, 42 or 43 BS receiver, unless the antenna path meets very stringent 3rd order PIM specification so that the PIM will not cause Band 22, 42 or 43 BS receiver desensitization.

6.2.2.1.3 Maximum Sensitivity Degradation (MSD) for band 4

When the uplink of carrier aggregation is allocated in band12, it will have the opportunity that UL's 3rd harmonic falls in band 4's DL. The 1/3 of 2110 MHz is 703.33 MHz, so if the uplink frequency is in the range of 703.33 – 716 MHz, the harmonic problem will arise. For the similarity between CA_4-12 and CA_4-17, the reference architecture, some of the test conditions and MSD analysis of CA_4-17 can be reused.

6.2.2.1.3.1 Reference architecture

The reference architecture of CA_4-12 is the same with CA_4-17 in subclause 6.2.1.1.3.2. A harmonic filter is used after the duplexer to suppress the 3rd harmonic of the low band uplink signal.

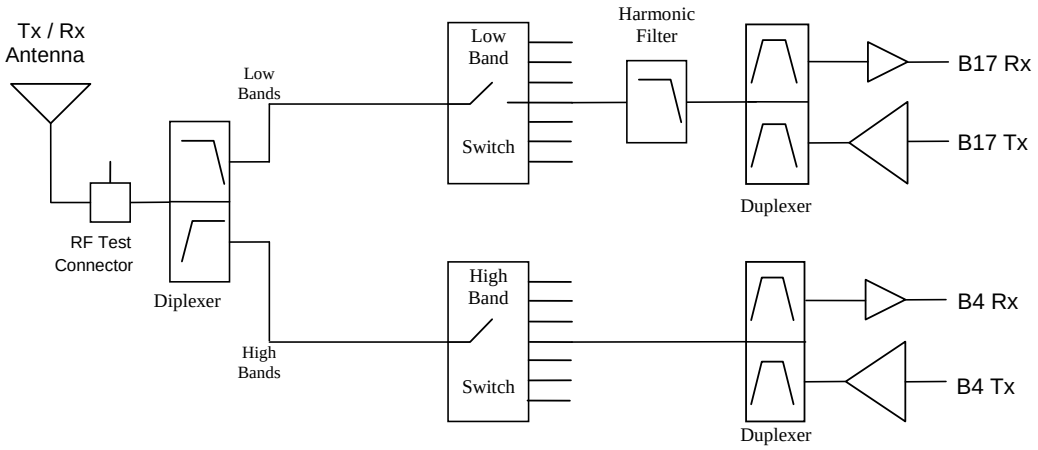

Figure 6.2.2.1.3.1-1: Reference architecture for Band 4 + Band 12

6.2.2.1.3.2 Test configuration of MSD

When B12's uplink frequency is in the range of 703.33-716 MHz, the 3rd harmonic will full overlap with band 4's DL. We propose reuse the MSD test configuration of CA_4-17 in subclause 6.2.1.1.3.1. When testing MSD, the UL frequency range uses B17 UL's frequency range, 704 MHz-716 MHz. The small bandwidth not included in CA_4-17 can be deduced from the conditions of bigger bandwidth.

Examples are provided below:

Table 6.2.2.1.3.2-1: Example MSD configuration of Band 4 and Band 12 channels.

Band 12 UL and DL			Band 4 DL	
Bandwidth	Frequency of Uplink	Frequency of Downlink	Bandwidth	Frequency of Downlink
5	706.5	736.5	1.4	2125.7
5	707.5	737.5	1.4	2128.7
5	712.5	742.5	1.4	2143.7
5	713.5	743.5	1.4	2146.7
5	706.5	736.5	3	2125
5	707.5	737.5	3	2128
5	712.5	742.5	3	2143
5	713.5	743.5	3	2146
5	706.5	736.5	5	2124
5	707.5	737.5	5	2127
5	712.5	742.5	5	2142
5	713.5	743.5	5	2145
5	706.5	736.5	10	2122
5	707.5	737.5	10	2125
5	712.5	742.5	10	2140
5	713.5	743.5	10	2143
10	709	739	1.4	2140
10	711	741	1.4	2146
10	709	739	3	2139
10	711	741	3	2145
10	709	739	5	2138.3
10	711	741	5	2144.3
10	709	739	10	2136.2
10	711	741	10	2142.2

The uplink configuration is shown in table 6.2.2.1.3.2-2.

Table 6.2.2.1.3.2-2: Uplink configuration for MSD of CA_4-12

CA Configuration	DL Bandwidth of Band 4 [MHz]	UL configuration of Band 12 [RB]
CA_4A-12A	1.4	2
	3	5
	5	8
	10	16

When testing MSD, the uplink power shall be set to P_{UMAX} as defined in subclause 6.2.5A of TS 36.101 [22].

6.2.2.1.3.3 MSD values

Although the frequency range of band 12 is wider than band 17, the analysis of MSD of band 4 and the insertion loss of harmonic filter/diplexer for CA_4-17 in subclause 6.2.1.1.3.3 can be used by CA_4-12. For the small bandwidth of CA_4-12, the harmonic level falling in the DL of high band is the same with bigger bandwidth, 5 MHz and 10 MHz. So the MSD values are shown in table 6.2.2.1.3.3-1.

Table 6.2.2.1.3.3-1: MSD for CA_4-12

Maximum sensitivity degradation [dB]							
CA Configuration	E-UTRA Bands	1.4 MHz	3 MHz	5 MHz	10 MHz	15 MHz	20 MHz
CA_4A-12A	4	15	12	10	7.5		
	12						

For two simultaneous DL and one UL the $\Delta T_{IB,c}$ and ΔR_{IB} values are shown in table 6.2.2.1.3.3-2, and in table 6.2.2.1.3.3-3:

Table 6.2.2.1.3.3-2: $\Delta T_{IB,c}$

Inter-band CA Configuration	E-UTRA Band	$\Delta T_{IB,c}$ [dB]
CA_4A-12A	4	0.3
	12	0.8

Table 6.2.2.1.3.3-3: $\Delta R_{IB,c}$

Inter-band CA Configuration	E-UTRA Band	$\Delta R_{IB,c}$ [dB]
CA_4A-12A	4	0
	12	0.5

It should be noted that the relaxations for CA_4A-12A, $\Delta T_{IB,c}$ and $\Delta R_{IB,c}$ are applied for each component carrier when operating either in single carrier or carrier aggregation configuration with a single uplink CC.

6.2.3 LTE Advanced Carrier Aggregation of Band 3 and Band 8

Table 6.2.3-1: 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_3-8	3	1710 MHz	–	1785 MHz	10, 15, 20	1805 MHz	–	1880 MHz	10, 15, 20	FDD
	8	880 MHz	–	915 MHz	5, 10	925 MHz	–	960 MHz	5, 10	FDD

6.2.3.1 List of specific combination issues

6.2.3.1.1 Channel bandwidths per operating band for CA

Table 6.2.3.1.1-1: Supported E-UTRA bandwidths per CA configuration for inter-band CA

CA operating / channel bandwidth								Bandwidth Combination Sets
E-UTRA CA Configuration	E-UTRA Bands	1.4 MHz	3 MHz	5 MHz	10 MHz	15 MHz	20 MHz	
CA_3A-8A	3				Yes	Yes	Yes	0
	8			Yes	Yes			
	3				Yes			1
	8			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 [22] when operating in single carrier mode.

6.2.3.1.2 Co-existence studies for CA_3-8 (1 UL/2 DL)

Table 6.2.3.1.2-1 summarizes frequency ranges where harmonics occur due to Band 3 or Band 8 for both UL and DL. It can be seen that distortions caused by 2nd order harmonics of Band 8 locates within the passband of Band 3. Additional filtering or de-sensitisation may be necessary.

Table 6.2.3.1.2-1: Impact of UL/DL Harmonic Interference

					2nd Harmonic		3rd Harmonic		2nd Harmonic		3rd Harmonic	
Band	UL Low Band Edge	UL High Band Edge	DL Low Band Edge	DL High Band Edge	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
8	880	915	925	960	1760	1830	2640	2745	1850	1920	2775	2880

Table 6.2.3.1.2-2 summarized frequency ranges where IMD occurs due to 2 DL (Band 3 and Band 8).

Table 6.2.3.1.2-2: 2nd order and 3rd order IMD Products (DL)

Band	DL low band edge	DL high band edge	DL 2nd order products	DL 3rd order products
3	1805 MHz	1880 MHz	845-955 MHz 2730 – 2840 MHz	2650 – 2835 MHz 3655 – 3800 MHz 4535 – 4720 MHz
8	925 MHz	960 MHz		

6.2.3.1.3 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 6.2.3.1.3-1, and in table 6.2.3.1.3-2:

Table 6.2.3.1.3-1: $\Delta T_{IB,c}$

Inter-band CA Configuration	E-UTRA Band	$\Delta T_{IB,c}$ [dB]
CA_3-8	3	0.3
	8	0.3

Table 6.2.3.1.3-2: ΔR_{IB}

Inter-band CA Configuration	E-UTRA Band	ΔR_{IB} [dB]
CA_3-8	3	0
	8	0

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

This subclause shall include all inter band CA combinations which can be included in the group low-low or high-high combinations without transmitter harmonics.

6.3.1 LTE-Advanced Carrier Aggregation of Band 3 and Band 7

Table 6.3.1-1: 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)	
		FUL_low – FUL_high		FUL_low – FUL_high		
CA_3-7	3	1710 MHz – 1785 MHz	5, 10, 15, 20 (note 1)	1805 MHz – 1880 MHz	5, 10, 15, 20	FDD
	7	2500 MHz – 2570 MHz	10, 15, 20 (note 1)	2620 MHz – 2690 MHz	10, 15, 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.						

6.3.1.1 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

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_3A-7A	3			Yes	Yes	Yes	Yes
	7				Yes	Yes	Yes

6.3.1.1.2 Co-existence studies for 1 UL/2 DL

Table 6.3.1.1.2-1 gives the intermodulation products for band 3 + band 7 CA with 2 DLs. For the 3-tone IMD analysis the maximum transmission as defined in table 6.3.1.1.1-1 is considered. None of the intermodulation products fall into the own receive bands. Considering bands in the same geographical area we observe that the BS distortion could fall into the BS receive bands of Band 8, 20, 22, 42 and 43.

With the performances of the current BS antenna system, transmit and receive path components, amp lifiers, pre-distortion algorithms and filters the IMDs generated within the band 8, 20, 22, 38, 42 and 43 receiver should be well below the receiver noise floor eliminating the possibility of receiver desensitization. Provided that the Bands 3 and 7 BS transmitters should not share the same antenna with Band 8, 20, 22, 38, 42 or 43 BS receiver.

Table 6.3.1.1.2-1: 2 DLs B3 + B7 IMD products

BS DL carriers	f1_low	f1_high	f2_low	f2_high
DL frequency (MHz)	1805	1880	2620	2690
2nd order harmonics frequency range (MHz)	3610 to 3760		5240 to 5380	
3rd order harmonics frequency range (MHz)	5415 to 5640		7860 to 8070	
Two-tone 2nd order IMD products	|f2_low – f1_high|	|f2_high – f1_low|	|f2_low + f1_low|	|f2_high + f1_high|
IMD frequency range (MHz)	740 to 885		4425 to 4570	
Two-tone 3rd 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)	920 to 1140		3360 to 3575	
Three-tone 3rd 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)	1785 to 1900		2600 to 2710	

Table 6.3.1.1.2-2 gives the intermodulation products for band 3 + band 7 CA with 1 UL. None of the intermodulation products fall into the own receive bands. For the UE the distortion could fall into the UE receive bands for Band 22 and 43. As a UE does not simultaneous operate in B3 + B7 and any other band this should be not a problem in case the UE supports these bands. These bands are also rather far away from band 3 and band 7 and we can assume that the UE filter can effectively attenuate these IMD products.

Table 6.3.1.1.2-2: 1 UL B3 + B7 harmonic products

UE UL carriers	f1_low	f1_high	f2_low	f2_high
UL frequency (MHz)	1710	1785	2500	2570
2nd order harmonics frequency range (MHz)	3420 to 3570		5000 to 5140	
3rd order harmonics frequency range (MHz)	5130 to 5355		7500 to 7710	

6.3.1.1.3 Co-existence studies for 2 UL/2 DL

Table 6.3.1.1.2-1 gives the intermodulation products for band 3 + band 7 CA with 2 ULs. For the 3-tone IMD analysis the maximum transmission BW as defined in table 6.3.1.1.1-1 is considered. None of the intermodulation products fall into the own receive bands.

Considering bands in the same geographical area we observe that the UE distortion could fall into the UE receive bands of Band 8, 20, 38 and 42. The magnitudes of these possible IMD products have to be further studied with respect to spurious emission limits into these bands.

Table 6.3.1.1.3-1: 2 ULs B3 + B7 IMD products

UE UL carriers	f1_low	f1_high	f2_low	f2_high
UL frequency (MHz)	1710	1785	2500	2570
Two-tone 2nd order IMD products	|f2_low – f1_high|	|f2_high – f1_low|	|f2_low + f1_low|	|f2_high + f1_high|
IMD frequency range (MHz)	715 to 860		4210 to 4355	
Two-tone 3rd 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)	850 to 1070		3215 to 3430	
Three-tone 3rd 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)	1690 to 1805		2480 to 2590	

6.3.1.1.4 ΔT_{IB} and ΔR_{IB} values

The following ILs for ETC combining band 3 + 7 were reported:

Table 6.3.1.1.4-1: Reported ILs for band 3 + 7 diplexer and quadplexers for ETC

E-UTRA bands	IL (dB)	IL (dB)	IL (dB)	IL (dB)
3	0.93	0.85	0.5	0.8
7	1.08	0.8	0.4	1.0

For the reported IL values there was no or only marginal difference for the Tx/Rx paths reported. With the average IL given as:

Table 6.3.1.1.4-2: Average Tx and Rx IL for combining band 3 and band 7 for ETC

Inter-band CA Configuration	E-UTRA Band	Tx IL [dB]	Rx IL [dB]
$\overline{IL}$	3	0.77	0.77
	7	0.82	0.82

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

Table 6.3.1.1.4-3: $\Delta T_{IB,c}$

Inter-band CA Configuration	E-UTRA Band	$\Delta T_{IB,c}$ [dB]
CA_3A-7A	3	0.5
	7	0.5

NOTE To meet the $\Delta T_{IB,c}$ requirements with state-of-the-art technology, an increase in power consumption of the UE may be required. It is also expected that as the state-of-the-art technology evolves in the future, this possible power consumption increase can be reduced or eliminated.

Table 6.3.1.1.4-4: ΔR_{IB}

Inter-band CA Configuration	E-UTRA Band	ΔR_{IB} [dB]
CA_3A-7A	3	0
	7	0

6.3.2 LTE-Advanced Carrier Aggregation of Band 5 and Band 12 (1 UL)

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	BS transmit / UE receive	
		F_{UL_low} – F_{UL_high}	F_{DL_low} – F_{DL_high}	
CA_5-12	5	824 MHz – 849 MHz	869 MHz – 894 MHz	FDD
	12	699 MHz – 716 MHz	729 MHz – 746 MHz	

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 band / channel bandwidth							
E-UTRA CA Band	**E-UTRA Bands**	**1.4 MHz**	**3 MHz**	**5 MHz**	**10 MHz**	**15 MHz**	**20 MHz**
CA_5A-12A	5				Yes		
	12				Yes		

6.3.2.1.2 Co-existence studies for CA_5-12

The combination of band 5 and band 12 has harmonic frequencies that are far removed from the component receive and transmit frequencies, in the UL and in the DL of the CA combination, as shown in table 6.3.2.1.2-1. Since there are no harmonics that coincide with the Rx bandwidth of either of the two bands participating in the CA, additional filtering or de-sensitization impacts are not anticipated.

Table 6.3.2.1.2-1: Impact of UL/DL Harmonic Interference

					2nd Harmonic		**3rd Harmonic**		**2nd Harmonic**		**3rd Harmonic**	
Band	**UL Low Band Edge**	**UL High Band Edge**	**DL Low Band Edge**	**DL High Band Edge**	**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**
5	824	849	869	894	1648	1698	2472	2547	1738	1788	2607	2682
12	699	716	729	746	1398	1432	2097	2148	1458	1492	2187	2238

Table 6.3.1.1.2-2 gives the frequency range of the second and third order inter-modulation products when two simultaneous ULs are active in band 5 and band 12. It can be seen that the inter-modulation products are not falling within the two bands and therefore no further relaxation is needed.

Table 6.3.2.1.2-2: Second-order and third-order inter-modulation products

Band	**UL low band edge**	**UL high band edge**	**DL low band edge**	**DL high band edge**	**UL 2nd order products**	**UL 3rd order products**
5	824 MHz	849 MHz	869 MHz	894 MHz	1523 – 1565 MHz	2097 – 2148 MHz 2347 – 2414 MHz 2472 – 2547 MHz
12	699 MHz	716 MHz	729 MHz	746 MHz		

6.3.2.1.2.1 Co-existence studies for 1 UL/2 DL

The 2nd and 3rd order harmonics and IMD products caused in the BS by transmitting of Band 5 and Band 12 DL carriers can be calculated as shown in table 6.3.2.1.2.1-1 below:

Table 6.3.2.1.2.1-1: Band 5 and Band 12 DL harmonics and IMD products

BS DL carriers	f1_low	f1_high	f2_low	f2_high
DL frequency (MHz)	729	746	869	894
2nd order harmonics frequency range (MHz)	1458	1492	1738	1788
3rd order harmonics frequency range (MHz)	2187	2238	2607	2682
2nd order IMD products	(f2_low – f1_high)	(f2_high – f1_low)	(f2_low + f1_low)	(f2_high + f1_high)
IMD frequency limits (MHz)	123	165	1598	1640
3rd 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 limits (MHz)	564	623	992	1059
3rd 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)	2327	2386	2467	2534
3rd order IMD products	(f1_low – f2_high + f2_low)	(f1_high + f2_high – f2_low)	(f2_low – f1_high + f1_low)	(f2_high + f1_high – f1_low)
IMD frequency limits (MHz)	704	771	852	911

It can be seen from table 6.3.2.1.2.1-1 that the 2nd and 3rd harmonics of Band 5 and Band 12 DL carriers may fall into the BS receive band of Bands 3, 4, 9, 10, 21, 38 and 41, while the 2nd IMD products caused by BS supporting carrier aggregation of Band 5 and Band 12 may fall into the BS receive band of Band 24, and the 3rd IMD products may fall into the BS receive band of Bands 7, 8, 12, 17, 20, 40 and 41. Note that the calculation in table 6.3.2.1.2.1-1 assumes the BS is transmitting with the whole 25 MHz DL frequency of Band 5 and the whole 17 MHz DL frequency of Band 12. If the BS is only transmitting an up to 10 MHz DL in Band 5 and a 10 MHz DL in Band 17 as stated in the WIDS, then the 3rd IMD products will not fall into the BS receive band of Bands 7, 12, 17, 40 and 41. In particular, the 3rd IMD products will not fall into the BS receive band of Bands 12 and 17 if the Band 5 DL bandwidth is not wider than 13 MHz.

Since Bands 3, 8, 9, 20, 21 and 38 are not intended for use in the same geographical area as Bands 5 and 12, the focus here will be on the harmonics and IMD falling into Bands 4, 10, 24 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 4, 10, 24 or 41 receiver would be well below the receiver noise floor eliminating the possibility of receiver desensitization, provided that Bands 5 and 12 BS transmitters do not share the same antenna with Band 4, 10, 24 or 41 BS receiver.

And it is recommended that Bands 5 and 12 BS transmitters should not share the same antenna with Band 4, 10, 24 or 41 BS receiver, unless the antenna path meets very stringent 2nd and 3rd order PIM specification so that the PIM will not cause Band 4, 10, 24 or 41 BS receiver desensitization. Note that antenna sharing may be allowed as the state-of-the-art continues to evolve in the future.

6.3.2.1.3 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 5 and band 12, for each of the Tx and Rx paths, from [21], are shown in table 6.3.2.1.3-1.

Table 6.3.2.1.3-1: IL values for band 5 + 12 diplexer and quadplexers (under ETC)

E-UTRA bands	IL (dB)	IL (dB)	IL (dB)	IL (dB)
5 Tx	0.7	0.6	2.3	0.7
5 Rx	0.7	0.7	1.8	0.8
12 Tx	0.5	0.3	1.2	0.5
12 Rx	0.5	0.3	1.8	0.5

For the reported additional IL values, the corresponding average additional IL values for the Tx and the Rx paths, from [21], are shown in table 6.3.2.1.3-2:

Table 6.3.2.1.3-2: Average Tx and Rx IL for combining band 5 and band 12 (under ETC)

Inter-band CA Configuration	E-UTRA Band	Tx IL [dB]	Rx IL [dB]
$\overline{IL}$	5	1.1	1.0
	12	0.6	0.8

For two simultaneous DLs and one UL the $\Delta T_{IB,c}$ and ΔR_{IB} values, from [21], are shown in table 6.3.2.1.3-3, and in table 6.3.2.1.3-4:

Table 6.3.2.1.3-3: $\Delta T_{IB,c}$

Inter-band CA Configuration	E-UTRA Band	$\Delta T_{IB,c}$ [dB]
CA_5A-12A	5	0.8
	12	0.4

Table 6.3.2.1.3-4: ΔR_{IB}

Inter-band CA Configuration	E-UTRA Band	ΔR_{IB} [dB]
CA_5A-12A	5	0.5
	12	0.3

6.3.3 LTE-Advanced Carrier Aggregation of Band 5 and Band 17 (1 UL)

Table 6.3.3-1: Inter-band non-contiguous CA

E-UTRA CA Band	E-UTRA Band	Uplink (UL) operating band	Downlink (DL) operating band	Duplex Mode
		BS receive / UE transmit	BS transmit / UE receive	
		F_{UL_low} – F_{UL_high}	F_{DL_low} – F_{DL_high}	
CA_5-17	5	824 MHz – 849 MHz	869 MHz – 894 MHz	FDD
	17	704 MHz – 716 MHz	734 MHz – 746 MHz	

6.3.3.1 List of specific combination issues

6.3.3.1.1 Channel bandwidths per operating band for CA

Table 6.3.3.1.1-1: Supported E-UTRA bandwidths per CA configuration for inter-band CA

E-UTRA band / channel bandwidth							
E-UTRA CA Band	E-UTRA Bands	1.4 MHz	3 MHz	5 MHz	10 MHz	15 MHz	20 MHz
CA_5A-17A	5			Yes	Yes		
	17			Yes	Yes		

6.3.3.1.2 Co-existence studies for CA_5-17

The 2nd and 3rd order harmonics and IMD products caused in the BS by transmitting of band 5 and band 17 DL carriers can be calculated as shown in table 6.3.3.1.2-1 below:

Table 6.3.3.1.2-1: Band 5 and Band 17 DL harmonics and IMD products

BS DL carriers	f1_low	f1_high	f2_low	f2_high
DL frequency (MHz)	734	746	869	894
2nd order harmonics frequency range (MHz)	1468	1492	1738	1788
3rd order harmonics frequency range (MHz)	2202	2238	2607	2682
2nd order IMD products	(f2_low – f1_high)	(f2_high – f1_low)	(f2_low + f1_low)	(f2_high + f1_high)
IMD frequency limits (MHz)	123	160	1603	1640
3rd 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)	574	623	992	1054
3rd 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)	2337	2386	2472	2534
3rd order IMD products	(f1_low – f2_high + f2_low)	(f1_high + f2_high – f2_low)	(f2_low – f1_high + f1_low)	(f2_high + f1_high – f1_low)
IMD frequency limits (MHz)	709	771	857	906
3rd order IMD products (with maximum channel bandwidth)	(f1_low – f2_BWmax)	(f1_high + f2_BWmax)	(f2_low – f1_BWmax)	(f2_high + f1_BWmax)
IMD frequency limits (MHz)	714	766	859	904

It can be seen from table 6.3.3.1.2-1 that the 2nd and 3rd harmonics of band 5 carriers may fall into the BS receive band of bands 3, 4, 9, 10, 38 and 41, while the 2nd IMD products caused by BS supporting carrier aggregation of band 5 and band 17 may fall into the BS receive band of band 24, and the 3rd IMD products may fall into the BS receive band of bands 7, 8, 12, 17, 20, 28, 40, 41 and 44. Note that the calculation in table 6.3.3.1.2-1 (except the last row) assumes the BS is transmitting with the whole 25 MHz DL frequency of band 5 and the whole 12 MHz DL frequency of band 17. Even if the BS is only transmitting 10, 15 or 20 MHz DL in band 5 and band 17 as stated in the WIDS, the 3rd IMD products may still fall into the same set of BS receive bands as shown in the last row in table 6.3.3.1.2-1.

Note that bands 3, 7, 8, 9, 20, 28, 38, 40 and 44 are not intended for use in the same geographical area as bands 5 and 17. Furthermore, the 3rd IMD products for band (5 + 17) DL at 714 – 766 MHz will not fall into the band 12 or 17 UL if the UL carrier is located out of this frequency range (e.g. locate the 10 MHz UL carrier for band 12 or 17 at 704 – 714 MHz) or the band 5 DL bandwidth is limited to not wider than 18 MHz.

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 4, 10 or 41 receiver would be well below the receiver noise floor eliminating the possibility of receiver desensitization, provided that bands 5 and 17 BS transmitters do not share the same antenna with band 4, 10 or 41 BS receiver.

Therefore, it is recommended that bands 5 and 17 BS transmitters should not share the same antenna with band 4, 10 or 41 BS receiver, or with band 12 or 17 BS receiver unless the band 12 or 17 UL carrier is located out of the frequency range at 714 – 766 MHz or the band 5 DL bandwidth is limited to not wider than 18 MHz, unless the antenna path meets very stringent 3rd order PIM specification so that the PIM will not cause band 4, 10, 12, 17 or 41 BS receiver desensitization.

6.3.3.1.3 ΔT_{IB} and ΔR_{IB} values

The insertion loss and ΔT_{IB} and ΔR_{IB} values for CA_5-17 are the same as those for CA_5-12.

The reported additional IL (Insertion Loss) values, based on implementation/simulation data, under ETC (Extreme Temperature Conditions) for combining band 5 and band 12 (same value used for combining band 5 and band 17), for each of the Tx and Rx paths, from [21], are shown in table 6.3.3.1.3-1.

Table 6.3.3.1.3-1: IL values for band 5 + 17 diplexer and quadplexers (under ETC)

E-UTRA bands	IL (dB)	IL (dB)	IL (dB)	IL (dB)
5 Tx	0.7	0.6	2.3	0.7
5 Rx	0.7	0.7	1.8	0.8
17 Tx	0.5	0.3	1.2	0.5
17 Rx	0.5	0.3	1.8	0.5

For the reported additional IL values, the corresponding average additional IL values for the Tx and the Rx paths, from [21], are shown in table 6.3.3.1.3-2:

Table 6.3.3.1.3-2: Average Tx and Rx IL for combining band 5 and band 17 (under ETC)

Inter-band CA Configuration	E-UTRA Band	Tx IL [dB]	Rx IL [dB]
$\overline{IL}$	5	1.1	1.0
	17	0.6	0.8

For two simultaneous DLs and one UL the $\Delta T_{IB,c}$ and ΔR_{IB} values, from [21], are shown in table 6.3.3.1.3-3, and in table 6.3.3.1.3-4:

Table 6.3.3.1.3-3: $\Delta T_{IB,c}$

Inter-band CA Configuration	E-UTRA Band	$\Delta T_{IB,c}$ [dB]
CA_5A-17A	5	0.8
	17	0.4

Table 6.3.3.1.3-4: ΔR_{IB}

Inter-band CA Configuration	E-UTRA Band	ΔR_{IB} [dB]
CA_5A-17A	5	0.5
	17	0.3

6.3.4 LTE inter-band carrier aggregation for bands 8+20 (1 UL)

CA_8-20 inter-band combination is designed to operate in the following bands defined in table 6.3.4-1. In this section only 2DL and 1UL case in considered.

Table 6.3.4-1: Inter band CA operating bands

E-UTRA CA Band	E-UTRA Band	Uplink (UL) operating band			Downlink (DL) operating band			Duplex Mode
		BS receive / UE transmit			BS transmit / UE receive			
		F_{UL_low} – F_{UL_high}			F_{DL_low} – F_{DL_high}			
CA_8-20	8	880 MHz	–	915 MHz	925 MHz	–	960 MHz	FDD
	20	832 MHz	–	862 MHz	791 MHz	–	821 MHz	

6.3.4.1 List of specific combination issues

6.3.4.1.1 Channel bandwidths per operating band for CA

Supported channel bandwidths per operating band for CA_8-20 are shown in table 6.3.4.1.1-1.

Table 6.3.4.1.1-1: 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_8A-20A	8			Yes	Yes		
	20			Yes	Yes		

6.3.4.1.2 Co-existence studies for for CA_8-20 (1 UL/2 DL)

The 2nd and 3rd order harmonics and IMD products caused in the BS by transmitting of Band 8 and Band 20 DL carriers can be calculated as shown in table 6.3.4.1.2-1 below:

Table 6.3.4.1.2-1: Band 8 and Band 20 DL harmonics and IMD products

BS DL carriers	f1_low	f1_high	f2_low	f2_high
DL frequency (MHz)	791	821	925	960
2nd harmonics frequency limits (MHz)	1582	1642	1850	1920
3rd harmonics frequency limits (MHz)	2373	2463	2775	2880
2nd order IMD products	(f2_low – f1_high)	(f2_high – f1_low)	(f2_low + f1_low)	(f2_high + f1_high)
IMD frequency limits (MHz)	104	169	1716	1781
3rd order IMD products	(2*f1_low – f2_high)	(f2*1_high – f2_low)	(2*f2_low – f1_high)	(2*f2_high – f1_low)
IMD frequency limits (MHz)	622	717	1029	1129
3rd 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)	2507	2602	2461	2741
3rd order IMD products	(f1_low – f2_high + f2_low)	(f1_high + f2_high – f2_low)	(f2_low – f1_high + f1_low)	(f2_high + f1_high – f1_low)
IMD frequency limits (MHz)	756	856	895	990
3rd order IMD products (with maximum channel bandwidth)	(f1_low – f2_BWmax)	(f1_high + f2_BWmax)	(f2_low – f1_BWmax)	(f2_high + f1_BWmax)
IMD frequency limits (MHz)	781	831	915	970

It can be seen from table 6.3.4.1.2-1 that the 2nd harmonics of BS transmitting in Bands 8 and 20 may fall into the BS receive band of Bands 2, 24, 25, 33, 35, 37 and 39, and the 3rd harmonics may fall into the BS receive band of Band 40, while the 2nd IMD products of BS supporting CA of Band 8 and Band 20 may fall into the BS receive band of Bands 3, 4, 9 and 10, and the 3rd IMD products may fall into the BS receive band of Bands 5, 6, 7, 8, 12, 13, 14, 17, 18, 19, 20, 26, 27, 28, 38, 41 and 44. Note that the calculation in table 6.3.4.1.2-1 (except the last row) assumes the BS is transmitting with the whole 35 MHz DL frequency of Band 8 and the whole 30 MHz DL frequency of Band 20. If the BS is only transmitting up to 10 MHz DL in Band 8 and Band 20 as prioritized in the WIDS, then the 3rd IMD products will not fall into the BS receive band of Bands 8 and 20 as shown in the last row in table 6.3.4.1.2-1.

Note that Bands 2, 4, 5, 6, 9, 10, 12, 13, 14, 17, 18, 19, 24, 25, 26, 27, 28, 35, 37, 39, 40, 41 and 44 are not intended for use in the same geographical area as Bands 8 and 20. Moreover, 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 3, 7, 33 or 38 receiver would be well below the receiver noise floor eliminating the possibility of receiver desensitization, provided that Bands 8 and 20 BS transmitters do not share the same antenna with Band 3, 7, 33 or 38 BS receiver.

Therefore, it is recommended that Bands 8 and 20 BS transmitters should not share the same antenna with Band 3, 7, 33 or 38 BS receiver, unless the antenna path meets very stringent 3rd order PIM specification so that the PIM will not cause Band 3, 7, 33 or 38 BS receiver desensitization.

If channel bandwidths larger than 10 MHz, i.e. 15 MHz and 20 MHz, would be supported for either Band 8 or Band 20, the 3rd order IMD products may fall into part of Band 8 and Band 20 receive band for some configurations (certain carrier location and channel bandwidth combinations). In such cases, it could be necessary to avoid sharing the same RF path for both transmitter and receiver side, or avoid such configurations in the BS.

6.3.4.1.3 ΔTIB and ΔRIB values

For 2 DL and 1 UL the $\Delta T_{IB,c}$ the incremental additional losses created by the need for a quadplexer design compared to independent duplexer filter are presented in table below:

Table 6.3.4.1.3-1: Reported incremental ILs for band 8 + 20 quadplexer compared to duplexer

E-UTRA bands	B8 UL	B20 UL	B8 DL	B20 DL
Vendor 1D1	0.9	1	0.7	0.8
Vendor 1D2	0.7	0.8	1.3	0.8
Vendor 1D3	0.6	0.9	0.8	0.9
Vendor 2	0.8	0.8	0.8	0.8
Vendor 3	0.5	0.5	0.5	0.5
Vendor 4	0.47	0.45	0.23	0.54
Vendor 5	1	0.8	1.2	1.4
Vendor 6	1	1	0.9	0.3
$\overline{IL}$	0.75	0.78	0.8	0.76

For 2 DL and 1 UL the $\Delta T_{IB,c}$ and ΔR_{IB} values are given in the tables below:

Table 6.3.4.1.3-2: $\Delta T_{IB,c}$

Inter-band CA Configuration	E-UTRA Band	$\Delta T_{IB,c}$ [dB]
CA_8A-20A	8	0.4
	20	0.4

Table 6.3.4.1.3-3: ΔR_{IB}

Inter-band CA Configuration	E-UTRA Band	ΔR_{IB} [dB]
CA_8A-20A	8	0
	20	0

6.3.5 LTE inter-band Carrier Aggregation Band 4 and Band 7 (1 UL)

Table 6.3.5.1 shows the operating bands for CA Band 4 and Band 7.

Table 6.3.5.1: Inter band CA operating bands

E-UTRA CA Band	E-UTRA Band	Uplink (UL) band		Downlink (DL) band		Duplex mode
		BS receive / UE transmit F_{UL_low} – F_{UL_high}	Channel BW (MHz)	BS transmit / UE receive F_{DL_low} – F_{DL_high}	Channel BW (MHz)	
CA_4-7	4	1710 MHz – 1755 MHz	5, 10	2110 MHz – 2155 MHz	5, 10	FDD
	7	2500 MHz – 2570 MHz	5, 10, 15, 20	2620 MHz – 2690 MHz	5, 10, 15, 20	FDD

6.3.5.1 List of specific combination issues

6.3.5.1.1 Channel bandwidths per operating band for CA

Table 6.3.5.1.1: Supported E-UTRA bandwidths per CA configuration for inter-band CA

E-UTRA band / channel bandwidth							
E-UTRA CA Band	E-UTRA Bands	1.4 MHz	3 MHz	5 MHz	10 MHz	15 MHz	20 MHz
CA_4A-7A	4			Yes	Yes		
	7			Yes	Yes	Yes	Yes

6.3.5.1.2 Co-existence studies for CA_4-7

Table 6.3.5.1.2-1 includes the 2nd and 3rd order harmonic products for band 3 + band 7 CA with 1 UL. Table 6.3.5.1.2-2 shows the 2nd and 3rd order harmonics and IMD products identified for Band 4 and Band 7 DL:

Table 6.3.5.1.2-1: Band 4 and Band 7 UL harmonics products

UE UL carriers	f1_low	f1_high	f2_low	f2_high
UL frequency (MHz)	1710	1735	2500	2570
2nd harmonics frequency limits (MHz)	3420	3510	5000	5140
3rd harmonics frequency limits (MHz)	5130	5265	7500	7710

Table 6.3.5.1.2-2: Band 4 and Band 7 DL harmonics and IMD products

BS DL carriers	f1_low	f1_high	f2_low	f2_high
DL frequency (MHz)	2110	2155	2620	2690
2nd harmonics frequency limits (MHz)	4220	4310	5240	5380
3rd harmonics frequency limits (MHz)	6330	6465	7860	8070
2nd order IMD products	(f2_low – f1_low) / f2_low – f1_high	(f2_high – f1_ high) / (f2_high – f1_ high)	(f2_low + f1_low) / f2_low + f1_ high)	(f2_high + f1_low) / f2_high + f1_high)
MD frequency limits (MHz)	510 / 465	580 / 545	4730 / 4775	4800 / 4845
2nd order IMD frequency range (MHz)	465-580		4730-4845	
3rd order IMD products	(2*f1_low – f2_low)/ (2*f1_low – f2_high)	(2*f1_high – f2_low) / (2* f1_high – f2_high)	(2*f2_low – f1_low) / 2*f2_low – f1_high)	(2*f2_high – f1_low) / 2*f2_high – f1_high)
IMD frequency limits (MHz)	1600 / 1530	1690 / 1620	3130 / 3085	3270 /3225
3rd order IMD products	(2*f1_low + f2_low) / 2*f1_low + f2_high)	(2*f1_high + f2_low) / (2* f1_high + f2_high)	(2*f2_low + f1_low) / 2*f2_low + f1_high)	(2*f2_high + f1_low) / 2*f2_high + f1_high)
IMD frequency limits (MHz)	6840 / 6910	6930 / 7000	7350 / 7395	7490 / 7535
3rd order IMD frequency range (MHz)	1530 – 1690 6840 - 7000		3085 – 3270 7350 - 7535	

With reference to the above tables, it can be seen that there are neither harmonic nor inter-modulation products falling within inter-band CA_4+7 operating frequency ranges. 2nd harmonics from the UE can fall into Band 22. However, it can be assumed that the harmonics will be attenuated by the duplex filter. It can be concluded that there is no issue on harmonic and intermodulation interference.

6.3.5.1.3 ΔT_{IB} and ΔR_{IB} values

The insertion loss and ΔT_{IB} and ΔR_{IB} values for CA_4-7 are derived by using the requirements and data for the configurations CA_1-7 and CA_3_7 as proxy.

For CA_4-7

1. the response for Band 7 TX needs to supply large attenuation at Band 4 RX and Band 7 RX, where Band 4 RX is a subset of Band 1 RX (cf. CA_1-7);

2. the response for Band 4 TX, a subset of Band 3 TX, needs to supply large attenuation at Band 4 RX and Band 7 RX, where Band 4 RX is at larger separation from the Band 4 TX compared to Band 3 RX;

3. the response for Band 7 RX needs to supply large attenuation at Band 4 TX and Band 7 TX, where Band 4 TX is a subset of Band 3 TX (cf. CA_3-7).

4. the response for Band 4 RX, a subset of Band 1 TX, needs to supply large attenuation at Band 4 TX and Band 7 TX, where Band 4 TX is at larger separation compared to Band 1 RX.

For the Band 7 TX of CA_4-7 (Item 1), the same requirement as for Band 7 TX of CA_3-7 is proposed: CA_3-7 has the same average reported IL as CA_1-7 for Band 7 TX (table 6.3.5.1.3-2).

For the Band 4 TX of CA_4-7 (Item 2), the same requirement as for Band 3 TX of CA_3-7 is proposed (table 6.3.1.1.4-3): even if the narrower Band 4 RX is at larger separation than the wider Band 3 RX, duplexer characteristics typically display fly-back, a decreased attenuation as the frequency is increased above the TX passband.

For the Band 7 RX of CA_4-7 (Item 3), the same requirement as for Band 7 RX of CA_3-7 could possibly be used. However, a penalty of ΔR_{IB} = 0.5 dB for Band 7 RX is proposed in view of the average reported IL of Band 7 RX for

CA_1-7 (table 6.3.5.1.3-2) with the same frequency separation between the lower receive band and the high transmit band.

For the Band 4 RX of CA_4-7 (Item 4), a ΔR_{IB} = 0.5 dB is proposed for Band 4 RX in view of the challenging matching for Band 4 and the legacy Band 4 reference sensitivity requirements.

For two simultaneous DL(s) and one UL the $\Delta T_{IB,c}$ and ΔR_{IB} values are shown in table 6.3.5.1.3-1 and table 6.3.5.1.3-2 [23]:

Table 6.3.5.1.3-1: $\Delta T_{IB,c}$

Inter-band CA Configuration	E-UTRA Band	$\Delta T_{IB,c}$ [dB]
CA_4A-7A	4	0.5
	7	0.5

Table 6.3.5.1.3-2: ΔR_{IB}

Inter-band CA Configuration	E-UTRA Band	ΔR_{IB} [dB]
CA_4A-7A	4	0.5
	7	0.5

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

This subclause shall include all inter band CA combinations which can be included in the group low-low or high-high combinations with transmitter harmonics.

6.5 Class A5. Combination except for A1 – A4

6.5.1 LTE Advanced Carrier Aggregation of Band 11 and Band 18

Table 6.5.1-1: Inter-band CA operating bands

E-UTRA CA Band	E-UTRA Band	Uplink (UL) band		Downlink (DL) band		Duplex mode
		BS receive / UE transmit	Channel BW (MHz)	BS transmit / UE receive	Channel BW (MHz)	
		F_{UL_low} – F_{UL_high}		F_{DL_low} – F_{DL_high}		
CA_11-18	11	1427.9 MHz – 1447.9 MHz	5, 10	1475.9 MHz – 1495.9 MHz	5, 10	FDD
	18	815 MHz – 830 MHz	5, 10, 15	860 MHz – 875 MHz	5, 10, 15	

6.5.1.1 List of specific combination issues

6.5.1.1.1 Channel bandwidths per operating band for CA

Table 6.5.1.1.1-1: 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_11A-18A	11			Yes	Yes		
	18			Yes	Yes	Yes	

6.5.1.1.2 Co-existence studies for CA_11-18

Although Band 11 and Band 18 are not categorized as A1 – A4, frequency separation between two bands are at least more than 500 MHz. In addition, as observed in table 6.5.1.1.2-1, the harmonic frequencies do not fall into the frequency ranges of both bands. Therefore we can conclude that there is no issue on harmonic interference.

Table 6.5.1.1.2-1: Impact of UL/DL Harmonic Interference

					2nd Harmonic		3rd Harmonic		2nd Harmonic		3rd Harmonic	
Band	UL Low Band Edge	UL High Band Edge	DL Low Band Edge	DL High Band Edge	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
11	1427.9	1447.9	1475.9	1495.9	2855.8	2895.8	4283.7	4343.7	2951.8	2991.8	4427.7	4487.7
18	815	830	860	875	1630	1660	2445	2490	1720	1750	2580	2625

Table 6.5.1.1.2-2 and 6.5.1.1.2-3 give the frequency range of the third and fifth order intermodulation product when two simultaneous ULs/DLs are active in Band 11 and Band 18. It can be seen that the intermodulation products are not falling within the two inter-bands and therefore no further relaxation is needed.

Table 6.5.1.1.2-2: Third order and fifth order intermodulation products (UL)

Band	UL Low Band Edge	UL High Band Edge	UL 3rd order products	UL 5th order products
11	1920 MHz	1980 MHz	182.1 – 232.1 MHz	N/A
18	815 MHz	830 MHz	2025.8 – 2080.8 MHz	2623.7 – 2713.7 MHz

Table 6.1.7.1.2-3: Third order and fifth order intermodulation products (DL)

Band	UL Low Band Edge	UL High Band Edge	UL 3rd order products	UL 5th order products
11	2110 MHz	2170 MHz	224.1 – 274.1 MHz 2076.8 – 2131.8 MHz	N/A 2677.7 – 4790 MHz

6.5.1.1.3 ΔT_{IB} and ΔR_{IB} values

Following values are reported for IL values of diplexer regarding Band 11 and Band. Note that maximum values are displayed.

Table 6.5.1.1.3-1: Reported ILs for Band 11 + 18 diplexer and quadplexers for ETC

		Maximum IL value (dB)			Average IL value (dB)
		Company A	Company B	Company C	
Tx	Band 11 UL	0.6	0.65	0.31 (Note)	0.52
	Band 18 UL	0.6	0.80	0.21 (Note)	0.54
Rx	Band 11 DL	0.6	0.65	0.22 (Note)	0.52
	Band 18 DL	0.6	0.80	0.34 (Note)	0.58
NOTE: Values are typical and reference due to its architecture (diplexer and duplexer are combined).					

According to information from table 6.5.1.1.3-1, following relaxations are allowed for the UE which supports inter-band carrier aggregation of Band 11 and Band 18. Values are applicable both for 1 UL and 2 UL.

Table 6.5.1.1.3-2: $\Delta T_{IB,c}$

Inter-band CA Configuration	E-UTRA Band	$\Delta T_{IB,c}$ [dB]
CA_11A-18A	11	0.6
	18	0.6

Table 6.5.1.1.3-3: ΔR_{IB}

Inter-band CA Configuration	E-UTRA Band	ΔR_{IB} [dB]
CA_11A-18A	11	0.6
	18	0.6

6.5.2 LTE Advanced Carrier Aggregation of Band 1 and Band 21 (1 UL)

Table 6.5.2-1: Inter-band CA

E-UTRA CA Band	E-UTRA Band	Uplink (UL) operating band BS receive / UE transmit[1] F_{UL_low} – F_{UL_high}	Downlink (DL) operating band BS transmit / UE receive F_{DL_low} – F_{DL_high}	Duplex Mode
CA_1-21	1	1920 MHz – 1980 MHz	2100 MHz – 2170 MHz	FDD
	21	1447.9 MHz – 1462.9 MHz	1495.9 MHz – 1510.9 MHz	
NOTE 1: A single uplink component carrier of either Band 1 or Band 21 shall be used at any time.				

6.5.2.1 List of specific combination issues

6.5.2.1.1 Channel bandwidths per operating band for CA

Table 6.5.2.1.1-1: Supported E-UTRA bandwidths per CA configuration for inter-band CA

E-UTRA CA Configuration	Supported E-UTRA bandwidths per CA configuration for inter-band CA					
CA_1A-21A	E-UTRA Bands	Band 1				
	Band 21	CBW	5 MHz	10 MHz	15 MHz	20 MHz
		5 MHz	Yes	Yes	Yes	Yes
		10 MHz	Yes	Yes	Yes	Yes
		20 MHz	Yes	Yes	Yes	Yes

6.5.2.1.2 Co-existence studies for CA_1-21

As the harmonic frequencies are far away from the receive and transmit bands of interest in the DL and UL (see table 6.5.2.1.2-1) and therefore we can conclude that there is no issue on harmonic interference.

Table 6.5.2.1.2-1: Impact of UL/DL Harmonic Interference

					2nd Harmonic		3rd Harmonic		2nd Harmonic		3rd Harmonic	
Band	UL Low Band Edge	UL High Band Edge	DL Low Band Edge	DL High Band Edge	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
21	1447.9	1462.9	1495.9	1510.9	2895.8	2925.8	4343.7	4388.7	2991.8	3021.8	4487.7	4532.7

6.5.2.1.3 ΔTIB and ΔRIB values

6.5.2.1.3.1 Diplexer data

6.5.2.1.3.1.1 Summary of diplexer data

The data of devices to deal with inter band CA from four device vendors are summarized in table 6.5.2.1.3.1.1-1.

Table 6.5.2.1.3.1.1-1: Diplexer/Quadplexer data from four device vendors (ETC)

		Vendor							
		1		2		3		4	
		Min [dB]	Max [dB]	Min [dB]	Max [dB]	Min [dB]	Max [dB]	Min [dB]	Max [dB]
IL	B21 Tx	–	0.43	–	0.64	–	0.30	–	0.59
	B21 Rx	–	0.45	–	0.64	–	0.30	–	0.62
	B1 Tx	–	0.65	–	0.76	–	0.50	–	0.49
	B1 Rx	–	0.50	–	0.76	–	0.50	–	0.52

6.5.2.1.3.1.2 Details of the data in table 6.5.2.1.3.1.1-1

6.5.2.1.3.1.2.1 Vendor 1

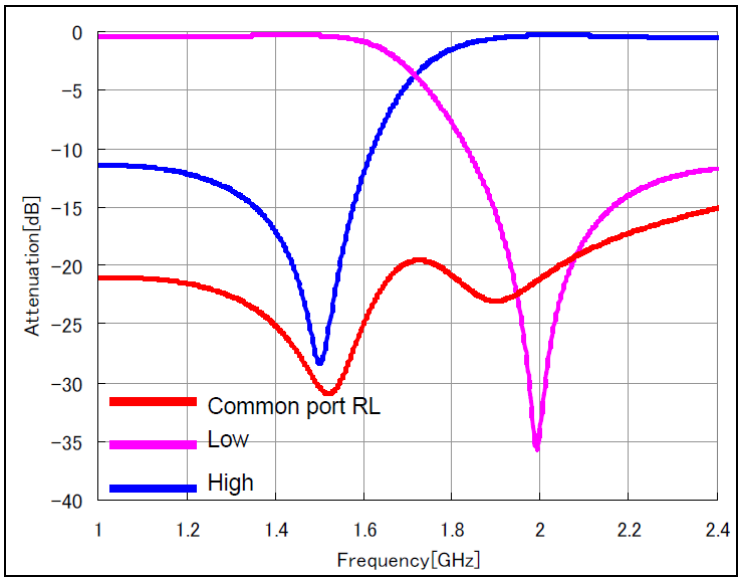

Figure 6.5.2.1.3.1.2.1-1: Diplexer simulation data from Vendor 1

6.5.2.1.3.1.2.2 Vendor 2

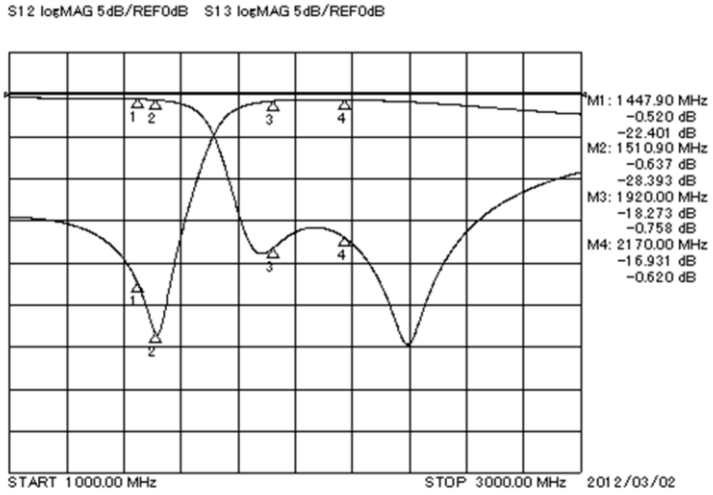

Figure 6.5.2.1.3.1.2.2-1: Diplexer data of real device from Vendor 2

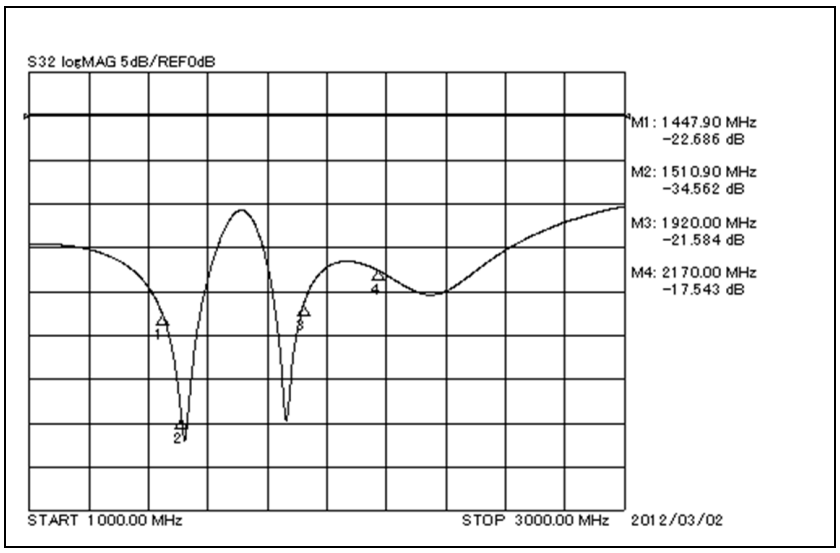

Figure 6.5.2.1.3.1.2.2-2: Diplexer data of real device from Vendor 2

6.5.2.1.3.1.2.3 Vendor 3

Table 6.5.2.1.3.1.2.3-1: Quadplexer data from vendor 3

		Frequency (MHz)		Duplexer Max [dB]	Quadplexer Typ/Min [dB]	Max [dB]	Difference [dB]
IL	B21 Tx	1448	1463	1.9	–	2.2	0.30
	B21 Rx	1496	1511	2.0	–	2.3	0.30
	B1 Tx	1920	1980	2.1	–	2.6	0.50
	B1 Rx	2110	2170	2.5	–	3.0	0.50
ISO	Tx to B21 Rx	1920	1980	–	61.2/55	–	–
	B21 Tx to B1 Rx	1448	1463	–	63/55	–	–

6.5.2.1.3.1.2.4 Vendor 4

In this sub-clause, a possible RF FE architecture is studied, which can obtain sufficient ISO between the two bands, reduce insertion loss, and minimize its size impact. In order to demonstrate its feasibility and effects, we compare the performances of three RF FE prototypes as explained in figure 6.5.2.1.3.1.2.4-1.

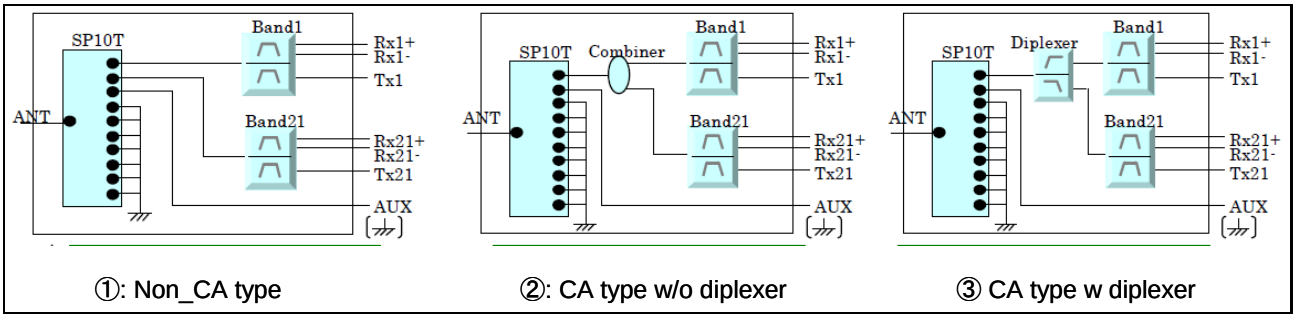

Figure 6.5.2.1.3.1.2.4-1: Prototype RF FE architectures to study

- (1) Non_CA type

This architecture is considered for comparison purpose, where it can not realize CA.

- (2) CA type w/o diplexer

In this architecture, ISO between B1 and B21 can be obtained through a combiner implemented in LTCC substrate.

- (3) CA type w diplexer

This architecture is also considered for comparison purpose.

Table 6.5.2.1.3.1.2.4-1 summarizes the data for the above three architectures. Note that RF FE IL in the table means the insertion loss including line losses and duplexer and switch losses or a combiner or diplexer losses.

Table 6.5.2.1.3.1.2.4-1: Comparison of three architectures for NTC

		Frequency [MHz]	(1) Non_CA [dB]	(2) CA_type w/o dip [dB]	(3) CA_type w dip [dB]	(2)-(1) [dB]	(3)-(1) [dB]	(3)-(2) [dB]
B1	TX RF FE I.L.	1920 – 1980	2.32	2.92	3.10	0.60	0.78	0.18
	RX RF FE I.L.	2110 – 2170	2.53	3.10	3.26	0.57	0.73	0.16
B21	TX RF FE I.L.	1447.9 – 1462.9	2.13	2.68	3.01	0.55	0.88	0.33
	RX RF FE I.L.	1495.9 – 1510.9	2.11	2.65	2.96	0.54	0.85	0.31
B1-B21	B1 TX - B21 RX	1920 – 1980	57.10	58.11	53.01	–	–	–5.10
	B1 TX - B21 RX	1495.9 – 1510.9	69.70	42.56	61.58	–	–	19.01
	B21 TX - B1 RX	1447.9 – 1462.9	79.70	55.45	63.05	–	–	7.60
	B21 TX - B1 RX	2110 – 2170	65.30	54.38	55.24	–	–	0.86
NOTE: (1) Based on 2 samples. (2) Based on 8 samples. (3) Based on 8 samples.								

Table 6.5.2.1.3.1.2.4-2: Comparison of three architectures for ETC (-30～+85 degrees)

		Frequency [MHz]	(1) Non_CA [dB] (Worst)	(2) CA_type w/o dip [dB] (Worst)	(3) CA_type w dip [dB] (Worst)	(2)-(1) [dB]	(3)-(1) [dB]	(3)-(2) [dB]
B1	TX RF FE I.L.	1920 – 1980	2.81	3.30	3.70	0.49	0.89	0.40
	RX RF FE I.L.	2110 – 2170	3.03	3.55	3.93	0.52	0.90	0.38
B21	TX RF FE I.L.	1447.9 – 1462.9	2.38	2.97	3.28	0.59	0.90	0.31
	RX RF FE I.L.	1495.9 – 1510.9	2.25	2.87	3.23	0.62	0.98	0.36
NOTE: (1) Based on 2 samples. (2) Based on 5 samples. (3) Based on 5 samples.								

From the above table, the followings can be observed.

- In the worst case, the total RF FE Tx IL post PA is 3.7 dB for the CA architecture with diplexer solution (3).
- On the other hand, for the CA architecture without diplexer solution (2), RF FE Tx IL post PA is 3.23 dB.
- The additional insertion loss of this CA architecture (2) is quite smaller than that of the CA architecture with diplexer (3).

6.5.2.1.3.2 Summary

The average insertion loss of the data presented in the above sub-clause is summarized in table 6.5.2.1.3.2-1.

Table 6.5.2.1.3.2-1: Additional insertion loss of diplexer and quadplexer (ETC)

		Vendors				
		1	2	3	4	Average
		Max [dB]	Max [dB]	Max [dB]	Max [dB]	[dB]
IL	B21 Tx	0.43	0.64	0.30	0.59	0.5
	B21 Rx	0.45	0.64	0.30	0.62	0.5
	B1 Tx	0.65	0.76	0.50	0.49	0.6
	B1 Rx	0.5	0.76	0.50	0.52	0.6

Annex A:
Change history

Change history							
Date	TSG #	TSG Doc.	CR	Rev	Subject/Comment	Old	New
2011-10	RAN4-60bis	R4-115471			Inter-band Carrier Aggregation Technical Report skeleton	N/A	x.y.z
2011-11	RAN4-61	R4-115883			The following TPs have been implemented: R4- 114865, “TP for TR ab.cde (inter-band CA): CA_3-7“ Editorial updates: Minor change of Document title Table of contents updated Minor table formatting corrections	x.y.z	0.0.1
2012-02	RAN4-62	R4-120282			The following TPs have been implemented: R4-115529, “CA_B5-B12: Core requirements text proposal” R4-115590, “Text Proposal of CA_1-7 for Inter-band TR ab.cde” R4-115774, “TP to inter-band CA TR: scope, background, definitions, WI related info” R4-116180, “TP for Band 7 and Band 20 requirements for inter-band CA” R4-116222, “TP for high/low interband CA combinations” R4-116223, “TP for inter-band CA BS” R4-116276, “TP, for TR ab.cde (inter-band CA): CA_3-5” Editorial updates: Changed order of subclause 6.1.2-6.1.7 (Band 20+7 moved) Table of contents updated Minor table formatting corrections	0.0.1	0.1.0
2012-03	RAN4-62bis	R4-122021			The following TPs have been implemented: R4-120123, “TP for TR ab.cde (inter-band CA): 1UL/2DL 2UL/2DL IMD study for B3 + B7 CA” R4-120322, “CA_B4-B12: Core requirements text proposal “ R4-120393, “TP for TR ab.cde (inter-band CA): Harmonic interference on UE and BS in CA_1_19” R4-120486, “CA Band 1 and 19 specific requirements in TS 36.101” R4-120539, “TP for 3GPP TR ab.cde V0.1.0 (2012-02) in Band 20+3” R4-120997, “Harmonics and/or Inter-Modulation distortions analysis on Inter-band CA for Band 1+18”R4-120394, “TP for TR ab.cde (inter-band CA): Harmonic interference on UE and BS in CA_1_21” R4-120490, “CA Band 1 and 21 specific requirements in TS 36.101” R4-120447, “Harmonics and/or Inter-Modulation distortions analysis on Inter-band CA for Band 11+18”	0.1.0	0.2.0
2012-05	RAN4-63	R4-122500			The following TPs have been implemented: R4-121136, “Text Proposal on Coexistence Studies of Harmonics and Intermodulation Products for Band Combination (4 + 13)” R4-121138, “Text Proposal on Coexistence Studies of Harmonics and Intermodulation Products for Band Combination (4 + 17)” R4-121309, “TP for TR ab.cde Diplexer insertion loss for Inter-band CA of Band 1 and Band 18” R4-121311, “TP for TR ab.cde: Diplexer insertion loss regarding Inter-band CA of Band 11 and Band18” R4-121506, “Update for Band 3+20 in 3GPP TR ab.cde V0.2.0 (2012-03)” R4-121881, “TP for TR ab.cde (inter-band CA): CA_3-5” R4-121942, “Additional information on Band 3 + Band 7 diplexer” R4-122106, “TP for TR ab.cde (inter-band CA): 1UL/2DL	0.2.0	0.3.0

					2UL/2DL IMD study for B20 + B3 CA" R4-122107, "TP for TR ab.cde (inter-band CA): 1UL/2DL 2UL/2DL IMD study for B20 + B7" R4-122108 , "TP for TR ab.cde (Inter-Band CA): LTE_CA_B3_B8 Core Requirements" R4-122131, "TP for TR ab.cde (inter-band CA): Diplexer data for CA_1_21" R4-122189, "Text Proposal on RRM Requirements for CA Class A1" Editorial changes: TR number updated to 36.850. Version number changed. The word "intra" in the guidance text have been replaced by "inter"		
2012-08	RAN4-64	R4-123719			The following TPs have been implemented: R4-122240, "TP for TR ab.cde (inter-band CA)" R4-122943, "TP for TR ab.cde (Inter-Band CA): Update of definitions, symbols and abbreviations" R4-123175, "Text Proposal on Coexistence Studies of Harmonics and Intermodulation Products for Band Combination (5 + 12)" R4-123354, "Optimization of supported E-UTRA bandwidths per CA configuration for B1+B19" R4-123517, "TP for TR ab.cde (inter-band CA): Diplexer data update for CA_1_21" R4-123541, "Text Proposal on RRM Requirements for Inter-Band CA Classes" R4-123582, "TP for TR ab.cde (inter-band CA) on IMD study of B1 + B7 CA" R4-123583, "CA_B5-B12: Core requirements text proposal" Editorial updates by the rapporteur: ● Version number changed ● Sub-clause 6.1.X.1, table 6.1.x-1 and sub-clause 6.4.2 have been deleted, since the same text for CA_1-21 also appears in sub-clause 6.5.2. Sub-clause 6.5.2 is the correct place for CA_1-21. ● Spelling errors corrected ● Minor table formatting corrections	0.3.0	0.4.0
2012-10	RAN4-64bis	R4-12xxxx			The following TPs have been implemented: R4-123704, "Text Proposal on Coexistence Studies of Harmonics and Intermodulation Products for Band Combination (2 + 17)" R4-123707, "Text Proposal on Coexistence Studies of Harmonics and Intermodulation Products for Band Combination (4 + 12) " R4-123709, "Text Proposal on Coexistence Studies of Harmonics and Intermodulation Products for Band Combination (8 + 20)" R4-123724, "Text proposal for inter-band CA_B5-B12" R4-124135, "TP for TR36.850 on IL value for CA_1-7" R4-124307, "TP for TR36.850 on Addition of Bandwidth Combination Set for LTE_CA_B3_B5" R4-124359, "Interband CA Class A2 MSD" R4-124488, "TP for 3GPP TR 36.850 V0.4.0 in Band 8+20 1UL" R4-124614, "TP of adding smaller bandwidth support in inter-band CA_4-12" R4-124627, "Band 4 + Band 17 MSD" R4-124647, "TP for TR 36.850 V0.4.0 Inter-band Carrier Aggregation: ΔR_{IB} and $\Delta T_{IB,c}$ for CA_3-7" R4-124694, "Text proposal - Harmonics and IMD analysis for Inter-band CA Band 4 and Band 7" Editorial updates by the rapporteur: ● Version number changed	0.4.0	0.5.0

					● Spelling errors corrected ● Minor table formatting corrections		
2012-11	RAN4-65	R4-126711			The following TPs have been implemented: R4-125020, “TP for TR 36.850 (Inter-Band CA): LTE_CA_B3_B8 Core Requirements“ R4-125035, “Text Proposal on Coexistence Studies of Harmonics and Intermodulation Products for Band Combination (4 + 5)“ R4-125036, “Text Proposal on Coexistence Studies of Harmonics and Intermodulation Products for Band Combination (5 + 17)“ R4-125360, “MSD for the small bandwidth of Band 4 and Band 12 carrier aggregation“ R4-125736, “Additional IL for Band 5 + Band 17 combination“ R4-125742, “Editorial corrections to TR 36.850 regarding CA_5-12“ Editorial updates by the rapporteur: ● Version number changed ● Removed the word “non-contigous” from some subclause headings ● Moved CA of band 5 and 17 from A1 to A3 ● Changed the order of the subclauses in subclause 6.1 and 6.3 ● Minor table formatting corrections	0.5.0	0.6.0
2013-01	RAN4-66	R4-130545			The following TPs have been implemented: R4-126962, “TP for TR 36.850 (Inter-Band CA) regarding CA_4-13 (1UL only)“ R4-126432, “Text Proposal on Coexistence Studies of Harmonics and Intermodulation Products for Band Combination (3 + 5)” R4-126605, “TP to 36.850: additional insertion loss for configuration CA_4A-7A” R4-126998, “TP introducing relaxations for Band 8+20 (1UL) in 3GPP TR 36.850” Editorial updates by the rapporteur: ● Version number changed ● Added a table to the Scope clause that lists all Rel-12 inter-band carrier aggregation combinations ● Texts on carrier aggregation of band 1 and band 7 have been removed from TR 36.850. ● Minor table formatting corrections	0.6.0	0.7.0
2013-03	RP#59	RP-130171			The document title have been changed from “Inter-band Carrier Aggregation Technical Report (Release 11)" to “LTE Advanced inter-band Carrier Aggregation (Release-11) ” Presented to TSG RAN for approval.	0.7.0	1.0.0
2013-03	RP#59				TR is appoved by RAN	1.0.0	11.0.0
2013-06	RP-60	RP-130766	001		Modification of band class A1 and A4 definitions	11.0.0	11.1.0