3GPP TR 36.840 V1.0.1 (2013-06)

Technical Report

3rd Generation Partnership Project;
Technical Specification Group Radio Access Networks;
LTE 450 MHz in Brazil Work Item Technical Report
(Release 12)

MCC selects keywords from stock list.

Keywords

<keyword[, keyword]>

3GPP

Postal address

3GPP support office address

650 Route des Lucioles - Sophia Antipolis
Valbonne - FRANCE
Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Internet

http://www.3gpp.org

Contents

Foreword

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

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

Version x.y.z

where:

x the first digit:

1 presented to TSG for information;

2 presented to TSG for approval;

3 or greater indicates TSG approved document under change control.

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

z the third digit is incremented when editorial only changes have been incorporated in the document.

1 Scope

The present document is a technical report for the introduction of LTE 450 in Brazil work item, which was approved at TSG RAN#57. The objective of this work item is to specify technical requirements for deploying LTE operation in 450 MHz band in Brazil.

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] RESOLUÇÃO No 558, DE 20 DE DEZEMBRO DE 2010 (in Portuguese) http://www.anatel.gov.br/Portal/verificaDocumentos/documento.asp?numeroPublicacao=255851&assuntoPublicacao=null&caminhoRel=null&filtro=1&documentoPath=255851.pdf

[4] RESOLUÇÃO Nº 584, DE 27 DE MARÇO DE 2012 (in Portuguese)

[5] PORTARIA Nº 71, DE 20 DE JANEIRO DE 1978 (in Portuguese)

[6] RESOLUÇÃO 82-1998 (in Portuguese)

[7] RESOLUÇÃO No 554, DE 20 DE DEZEMBRO DE 2010 (in Portuguese)

[8] RESOLUÇÃO No 446, DE 17 DE OUTUBRO DE 2006 (in Portuguese).

[9] RESOLUÇÃO SNC No 52, DE 6 DE JUNHO DE 1991 (in Portuguese).

[10] RESOLUÇÃO No 498, DE 27 DE MARÇO DE 2008 (in Portuguese).

[11] RESOLUÇÃO No 284, DE 7 DE DEZEMBRO DE 2001 (in Portuguese).

[12] R4-130502, "LTE 450 MHz coexistence with Digital TV broadcast system," CPqD

[13] APT/AWG/REP-24, "Implementation Issues Associated with Use of the Band 698 – 806 MHz by Mobile Services"

[14] 3GPP2 C.S0057-C_v1.0, "Band Class Specification for cdma2000 Spread Spectrum Systems"

[15] HARMONIZED USE OF THE 450-470 MHZ BAND FOR FIXED AND MOBILE BROADBAND WIRELESS SERVICES PARTICULARLY IN UNDERSERVED AREAS

[16] R4-131157, "Further consideration on frequency band arrangement", Huawei, HiSilicon

[17] R4-131660, "LTE450 UE Self Desense", Motorola Solutions

3 Definitions 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].

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].

SARC	Broadcast Auxiliary Service
SCM	Multimedia Communication Service
SLE	Specialized Limited Service
SLMP	Private Mobile Limited Service
SLP	Private Limited Service
SLP-Aero	Airport Ground Communications
SMM	Maritime Mobile Service
SMP	Personal Mobile Service
STFC	Fixed Switched Telephony Service

4 Background

In June 2012 Brazil released licenses in the bands 2.6 GHz and 450 MHz. In particular, at 450 MHz the band plan allocation is the following: uplink 451-458 MHz and downlink 461-468 MHz. The entire block (7+7 MHz) has been assigned to a single operator, while different operators have been assigned the band in different states (differentiation on geographical area).

Currently, 3GPP specifications does not cover 450 MHz band. It was approved in RAN#57 to open a new WI in RAN4 to specify LTE to operate in the 450 MHz band taking into account the band plan indicated above.

As part of the work item, suitable band arrangement such as duplex gap and Rx/Tx separation assumptions need to be identified for this new band and requirements will be developed based on the findings of this activity.

4.1 Work item objective

The objective of the present work item is to specify technical requirements for deploying LTE operation in 450 MHz band in Brazil. It is composed of the following work tasks:

a) Core RF requirements for RAN4 specifications

b) Performance requirements for RAN4 specifications

c) Conformance testing in RAN5 specifications (to follow)

5 Band plan allocation and regulatory background

The Brazilian Agency of Telecommunications, ANATEL, approved Resolution 558 [3] on December 20, 2010 defining the Regulation of Channelization and Conditions of Use of Spectrum in the 450 – 470 MHz band. Under this regulation, the 450 – 470 MHz band will be cleared and allocated to deliver fixed and mobile services, including the full range of IMT services nationwide in Brazil. Incumbent users of the 450 – 470 MHz frequency bands will be migrated to an alternative spectrum band, to avoid interference and to facilitate Brazil's goal in providing coverage to its low population density areas. The 7+7 MHz spectrum 451 – 458 / 461 – 468 MHz is allocated on a primary, non-exclusive basis for personal mobile service (SMP), fixed switched telephony service (STFC), as well as multimedia communication services (SCM). The frequency plan pre-and post-restructuring are shown below in Figure 5-1.

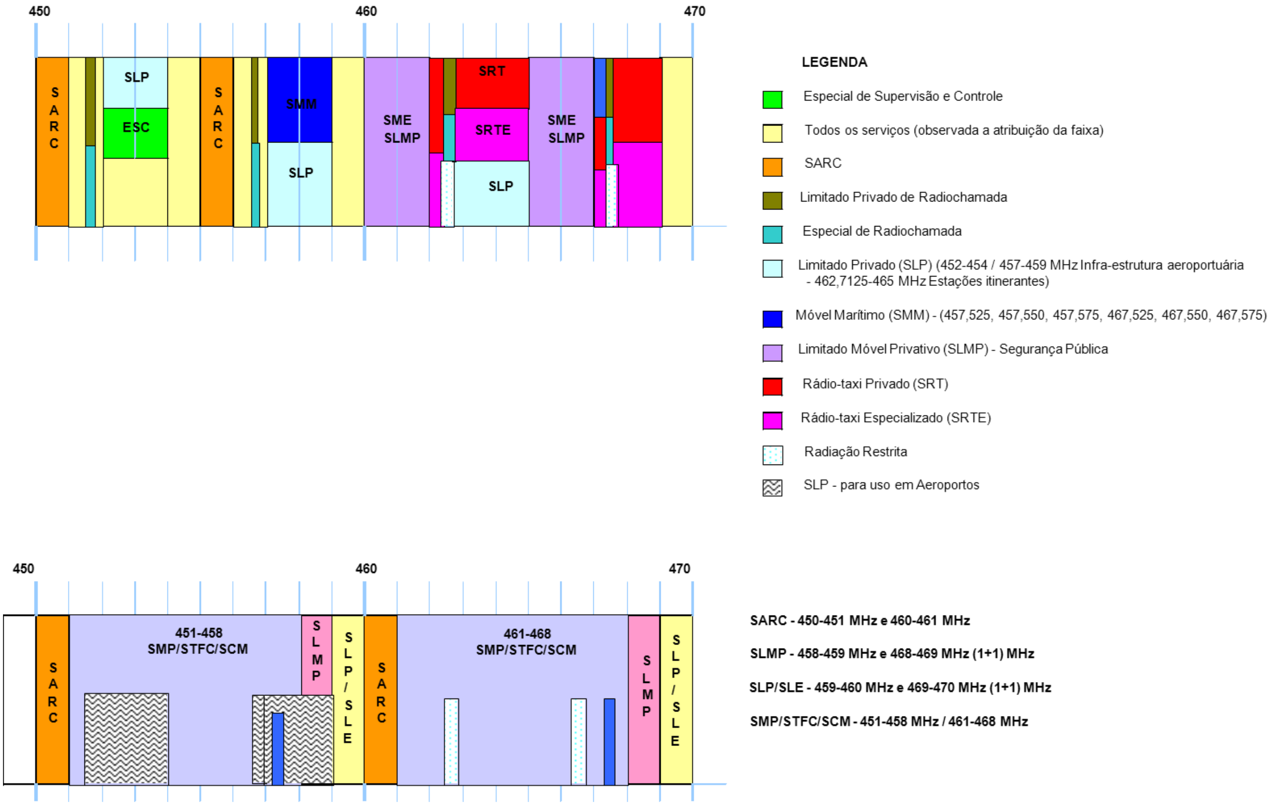


Figure 5-1: 450 - 470 MHz spectrum plan in Brazil

It can be seen that there are a number of services operating in adjacent spectrum as well as within the spectrum under consideration.

Current regulatory rules at Brazil provide the basis for establishing the requirements for coexistence analysis within 450-470 MHz band, with focus on adjacent services to 451-458/461-468 MHz sub-bands. The rules are defined in terms of channel characteristics, such as width, spacing, nominal center frequency, output or effective radiated power and some antenna issues, are defined in the Frequency Band Channelization and Usage Conditions regulations, as shown in table below.

Table 5.1: Frequency band channelization and usage conditions regulations related to the 450-470 MHz band

Frequency Sub-Bands	Service(s)	Regulation
451-458 MHz and 461-468 MHz 458-460 MHz and 468-470 MHz 450-451 MHz and 460-461 MHz	STFC, SCM, SMP SLMP, SLP, SLE SARC (Note)	#558 (Dec-20th/2010) [3]
450-451 MHz and 460-461 MHz	SARC	#584 (Mar-27th/2012) [4]
451.6-454 MHz and 456.6-459 MHz	SLP-Aero	#446 (Oct-17th/2006) [8]
457.6-457.6 MHz and 467.5-467.6 MHz	SMM	SNC #52 (Jun-6th/1991) [9]

NOTE: The SARC service frequency allocation changes are established in [3], but the complete frequency usage and power limits are specified in [4].

The out-of-band interference characteristics, such as transmission mask, out-of-band spurious emissions and maximum output power, are defined in the Product Certification Requirements regulations, in clause 5.5.

5.1 In-band services

According to current regulation [3], 451-458 MHz / 461-468 MHz sub-bands are allotted for SMP, STFC and SCM services. Any antenna polarization and azimuth pattern for sector coverage can be applied, as well any arrangement of them. When a sectorized system is adopted in locations with more than 100,000 inhabitants the sector shall be limited to 120 degrees.

Within the band are Private Limited Service (SLP) from 451.5875 – 454 MHz and 456.5875 – 459 MHz for use in airports as primary service without exclusivity. For the protection of these services, the regulations require an exclusion zone of 10 km within the location of the airport. However, in accordance with [3], it is possible to establish coordination agreements. Within the band are also Maritime Mobile Services (SMM) occupying sub-bands 457.5 – 457.6 MHz and 467.5 – 467.6 MHz. The regulations require that new operations within the band engage in prior coordination with operators of these SMM services to address coexistence. Thus, in all of these cases of in-band services, the regulations require that coexistence is achieved by deployment and coordination methods rather than by establishing emission limits. STFC and SCM are normally licensed to the same operator as SMP with differences related to services provided to public or private regime with differnig levels of obligations, fees, and rates. The usage and coordination of these three classes of service are controlled by the operator itself. *Thus, coexistence with in-band services will not be treated by 3GPP specifications.*

5.2 Broadcast auxiliary service (SARC)

As described in Article 5 and Article 8 of [3], the sub-bands 450 – 451 MHz and 460 – 461 MHz are allocated to Broadcast Auxiliary Service (SARC). These services are governed by [4], [5], and [6], and apply to Electronic news gathering, internal dispatch, studio-transmitter link, remote-control and telemetering at Brazil.

According to [3] and [4], these services are operated in 12.5 or 25 kHz channels, with frequency modulation. The channel spacing and nominal carrier frequencies are defined by equations below

$$f_N \text{ (MHz)} = [(N \times 0.025) + 450], N = 1 \text{ to } 40$$

$$f_N \text{ (MHz)} = [(N \times 0.025) + 460], N = 1 \text{ to } 40$$

The maximum output power is summarized below

Table 5.2: Maximum output power allowed for SARC transmitter

Frequency Range	Maximum transmitted power (W)		Maximum e.i.r.p. (dBm)	
	Fixed station	Mobile station	Fixed station	Mobile station
Subrange E (450 – 451 MHz)	20	20	61	54
Subrange F (460 – 461 MHz)	20	20	61	54

Note that [5] refers to subrange F as 455 – 456 MHz, but this has been subsequently reallocated to 460 – 461 MHz. Duplex direction is not specified so it can be assumed that either direction (uplink or downlink) is permitted in either of these frequency ranges. The modulation characteristics of the transmitter, applicable to both fixed and mobile stations, are required as follows

a) audio response (with pre-emphasis of 75 or 50 us)

a.1) when using a 25 KHz channel: + 2 dB between 300 and 3000 Hz (reference 1000 Hz);

a.2) when using two channels of 25 kHz: + 1.5 dB between 30 Hz and 10 000 (reference 1000 Hz);

b) *level of harmonics and spurious: attenuated at least 60 dB relative to the fundamental*;

c) harmonic distortion:

c.1) when using a 25 KHz channel: less than 10%;

c.2) when using two channels of 25 KHz: less than 2%;

d) FM noise output below 100% modulation across the audio frequency range;

d.1) when using a 25 KHz channel: a minimum of 40 dB (reference 400 Hz);

d.2) when using two channels of 25 kHz: 50 dB minimum (reference 400 Hz);

e) Frequency tolerance: 0.002%.

Aside from FM de-emphasis, no receiver requirements such as blocking or adjacent channel rejection requirements are mandated.

5.3 Private mobile limited service (SLMP) and Private Limited service (SLP/SLE)

As described in Article 4 in the resolution of [3], the sub-bands 458 – 459 MHz for uplink (mobile transmit) and 468 – 469 MHz downlink (basestation transmit) are allocated to Private Mobile Limited Service (SLMP), consisting of channel numbers 1 – 80.

As described in Article 6 in the resolution of [3], the sub-band 459 – 460 MHz for uplink (mobile transmit) and 469 – 470 MHz downlink (basestation transmit) are allocated to Private Limited Service (SLP) and Specialized Limited Service (SLE), consisting of channel numbers 81 – 160.

The channels can be aggregated or not, and in any case the transmission carrier must be positioned at the center of the aggregated channel. There is no constraint on the number of aggregated channels. There is no mention in the regulation about changes on spurious specifications when channels are aggregated. Thus, we assume that the same emission attenuation and frequency offset requirements of Table 5.3-2 apply regardless of aggregation.

The private limited services (SLMP, SLP, SLE) operating in the 458 – 460 MHz and 468 – 470 MHz should limit their input power to the antenna according to the following

Table 5.3-1: Maximum output power allowed for SLMP, SLP, SLE transmitter

Station	Power at antenna (Watts)
Basestation	250
Fixed or mobile terminal	25

These services are operated in 12.5 kHz channels, which can be aggregated. The emission mask for 12.5 kHz systems for both basestation and mobile operating in 400 MHz band is given in [7] as

Table 5.3-2: Spurious emission attenuation requirement for SLMP, SLP, SLE transmitter

Frequency offset (f_d) from channel edge	Attenuation (dB)
5.825 to 12.5 kHz	7.27*(f_d - 2.88)
>12.5 kHz	min(70, 50+10*log(P))

P is the transmitter power in Watt.

No receiver requirements such as blocking or adjacent channel rejection requirements are mandated. Furthermore, no constraints on antenna polarization and azimuth pattern are specified.

5.4 Adjacent services to 450-470 MHz band

In current Brazilian regulatory scenario, adjacent services to 450-470 MHz band are also recommended to be in the scope of coexistence analysis. Indeed, TS 36141 considers in-band blocking in a frequency range up to 20 MHz around the channels.

The 470-490 MHz sub-band is the first 20 MHz of the 470-806 MHz band, which is currently designated by ANATEL to UHF TV service. The coexistence between LTE broadband service in 450 MHz band and the UHF TV service can be evaluated taking into account the requirements specified in Resolutions 498 [10] and 284 [11].

Even though the 430-450 MHz band should be considered for coexistence analysis, the 430-440 MHz band is allotted by ANATEL for Amateur Radio Service. However, the occupation of the 430-440 MHz band is quite sparse at Brazil and the interference probability of this service on 450 MHz band is very low. Thus, the proposal is to focus on the coexistence analysis of 440-450 MHz band, considering adjacent services STFC, SMP, SME and SMC, as per table below, based on the requirements already detailed in previous clauses.

Table 5.4: Narrowband services within 360 - 450 MHz range

Regulation			75	78	169	375	395	452	506	556	557
MHz	MHz	NA	1998	1998	1999	2004	2005	2006	2008	2010	2010
360,000	380,000									SME/SLMP/SLE	
380,000	400,000										SLMP-SP/SME/SLMP/SCM/STFC
400,150	401,000		LEO-E>T								
401,000	402,000	NA									
402,000	405,000								RR		
405,000	406,100	NA									
406,100	408,900			STFC	STFC		SME/SMC				
408,900	410,000			STFC	STFC						
410,000	411,675			STFC	STFC	STFC/SMP					
411,675	415,850			STFC		STFC/SMP	SME/SMC				
415,850	420,000					STFC/SMP					
420,000	421,675					STFC/SMP					
421,675	425,850			STFC		STFC/SMP	SME/SMC				
425,850	428,625			STFC	STFC	STFC/SMP					
428,625	430,000			STFC	STFC	STFC/SMP	SME/SMC				
430,000	440,000							SRA	SRA		
440,000	442,800					STFC/SMP	SME/SMC				
442,800	448,625					STFC/SMP					
448,625	450,000					STFC/SMP	SME/SMC				

5.5 Product Certification Requirements regulations

Regulations are established for product certification without regard to specific band usage, for example in 361/2004. Such regulations typically include spurious emissions, frequency stability, and other equipment characteristics. There is also an output power limitation in the case that the specific frequency band regulation does not define it. Both the product certification requirements as well as the frequency specific requirements, for example in 558/2010. If the requirements conflict, it is expected that the certification authority (OCD - "Designated Certification Body") would make a decision possibly consulting ANATEL.

Table 5.5-1 shows the regulation documents to be considered for evaluating potential interference among services, based on currently Product Certification Requirements for services related to 450-470 MHz band, as per ANATEL. Table 5.5-2 describes the most relevant requirements defined in such regulations, for the purpose of coexistence analysis.

Table 5.5-1: Product Certification Requirements for services

Service	Regulation	Equipment
SMP	554/2010	Base Station Tcvr
Limited Service (SLP, SLE, SLMP)	361/2004	Tcvr (Fixed, Mobile or HH)
Public service (STFC, SCM)	359/2004	Digital Tcvr < 1GHz
SARC	584/2012	Tx and Rx
TV – Analog	284/2001	Tx
TV – Digital	498/2008	Tx

Table 5.5-2: Relevant requirements for coexistence analysis

Service	Regulation	Scope	Output Power	Spurious Emissions
Mobile Public Service (SMP)	#554/2010	Base Stations and Repeaters for the Mobile Personal Services.	Shall comply with the frequency band usage conditions.	For LTE: 3GPP TS36141V9.8.0 clause 6 (Transmitter Characteristics) and clause 7.7 (Receiver Characteristics - Spurious Emissions).
Limited Services (SLP, SLE, SLMP)	#361/2004	Analog FM and PM, half-duplex (PTT), single-channel, voice transceiver, that operates at frequencies bellow 1 GHz.	Shall comply with the frequency band usage conditions or, if it's not specified, it shall be limited to +40 dBm.	Shall be limited to the mask shown in Figure 5.5-1. The spurious and harmonics levels, measured at the antenna connector, with frequency offset greater than 250% of the channel spacing, shall not exceed the limit established in Table 5.5-3 for f'/Δf = 2.5.
Fixed Public Services (STFC, SCM)	#359/2004	Transmitters and transceivers for Point-Multipoint Fixed services.	Shall comply with the frequency band usage conditions or, when not specified, it shall limited to +43 dBm.	Shall be limited to the mask shown in Table 5.5-3. Receiver spurious emissions - shall comply with ITU-R SM329-9 recommendation.
Broadcast Ancillary Service (SARC)	#584/2012	Transmitters and transceivers for the Ancillary Broadcast service, with channel bandwidth of 12.5 kHz or 25 kHz.	20 W, for fixed or mobile stations, and limited to +61 dBm e.i.r.p. for fixed stations and to +54 dBm e.i.r.p. for mobile stations.	Not specified.
Broadcast Analog TV	#284/2001	Transmitters for Analog TV Broadcast service	Limited by the values shown in Table 5.5-4.	Limited to the values shown in Table 5.5-5.
Broadcast Digital TV	#498/2008	Transmitters for Digital TV Broadcast service.	Limited by the values shown in Table 5.5-6.	Shall be limited to -60 dBc or to 20mW in any case, for output power greater then 25 W. For transmitters with less than 25 W of output power, the spurious emissions shall be limited to 25 uW. Table 5.5-7 shows these limits.

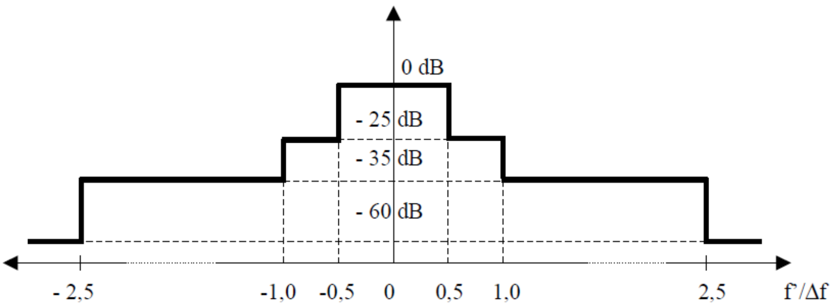


Figure 5.5-1: Emission Spectrum Mask

Table 5.5-3: Transmission mask

	f'/ΔF					
M	0	0,5	0,8	1,0	1,5	2,5
2 e 4	0 dB	0 dB	-25 dB	-25 dB	-45 dB	-45 dB
16	0 dB	0 dB	-32 dB	-32 dB	-45 dB	-45 dB

f' - frequency shift from the center frequency
Δf - Channel spacing
M - Number of modulation levels

Table 5.5-4: Output maximum power for UHF analog TV transmitters

Station Class	Output Power (ERP)	Protected Contour (km)
Special	1,600 kW (32dBk)	53
A	160 kW (22dBk)	40
B	16 kW (12 dBk)	26
C	1,6 kW (2,04 dBk)	14

NOTE: The UHF repeater transmitter output power (ERP) is limited to 360 W.

Table 5.5-5: Out-of-channel spurious emissions for Analog TV transmitters

Frequency offset related to the lower channel limit (MHz)	Frequency offset related to the upper channel limit (MHz)	Minimum attenuation related to the video peak power (dB)
0	0	20
-2,33	-	42
-3,00	+3,00	40+10logP(W) (P<100W) 60 (P>100W) Limited to 12mW

NOTE: Any spurious emissions at frequency shift greater than 3 MHz up or down the channel limits shall be limited to the values shown in Table 5.5-5 for +/- 3MHz frequency offsets.

Table 5.5-6: Standard ERP limits for 93% of total allocated UHF Digital TV Channels

kW	No.	Ratio
80,00	100,00	6%
8,00	493,00	27%
0,80	677,00	38%
0,08	406,00	23%

Table 5.5-7: Maximum spurious emission for Digital TV transmitters

Frequency offset related to the OFDM carriers central frequency (MHz)	Minimum attenuation related to the channel mean power (dB)
> 15	60 dB (P>25W) limited to 20 mW
< 15	25 uW (P<25W)

6 List of band specific issues for introduction of LTE 450 in Brazil

- General issues
  - Coexistence with existing systems in adjacent spectrum
    - Coexistence with SARC
    - Coexistence with limited service (SLP, SLE, SLMP)
    - Coexistence with Broadcast TV
  - Frequency band arrangement
- E-UTRA issues
  - UE duplexer
  - UE transmitter requirements
  - UE receiver requirements

7 General issues

7.1 Coexistence with existing systems in adjacent spectrum

Figure7.1-1 shows the LTE 450 spectrum and other system spectrum around 450 MHz in Brazil. When considering the LTE deployment it is needed to study the interference issues from adjacent systems, such as SARC, SLMP, SLP/SLE and analog TV (ATV) or digital TV (DTV) system.

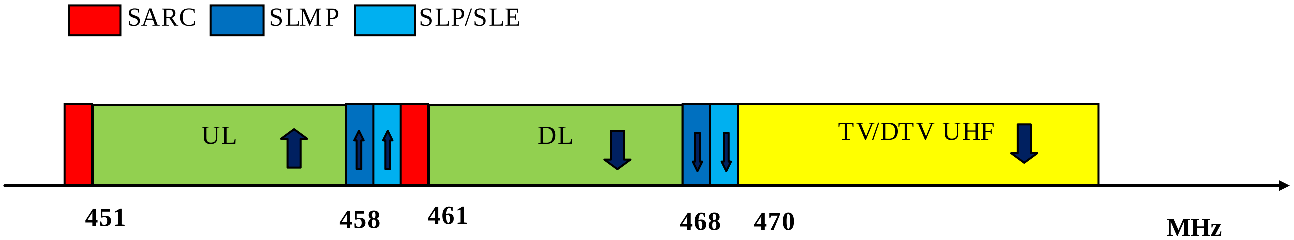


Figure 7.1-1: Frequency spectrum around 450MHz

7.1.1 UE

To evaluate the coexistence requirements for UE's operating in the proposed LTE 450 MHz band, we consider the impact of adjacent systems to receiver performance and transmitter performance. For the receiver, we consider transmitters in adjacent bands whose power may cause receiver blocking and whose out-of-band emissions may fall into the receive band increasing the noise floor. For the transmitter, we consider the out-of-band emissions generated which may fall in-band into the adjacent band's receiver. One method to evaluate these conditions is to observe the regulatory requirements for systems operating in adjacent bands. The regulatory requirements provide a worst-case bound on the adjacent systems transmitter power, out-of-band emissions, as well as provide limits on the allowable transmission power and out-of-band emissions from the device operating in the 450 MHz band. This method is useful for worst case analysis when studied in conjunction with a deterministic approach on minimum coupling loss between aggressor and transmitter. However, such a method is often overly pessimistic with respect to actual operation.

In this case, we take a glance at the coexistence requirement implied by such a method. The regulatory requirements of greatest consequence are those for the system operating immediately adjacent to the proposed LTE 450 band. For this case, the UE filter is not able to provide any attenuation. As summarized in [1] and [2] the regulations in Brazil allow a broadcast auxiliary service (SARC) to operate in sub-bands 450 - 451 MHz and 460 - 461 MHz, immediately adjacent to the 451 - 458 MHz / 461 - 468 MHz band authorized for mobile broadband. There is no guardband and since the duplex direction is not specified, either of the sub-bands can be transmit or receive.

7.1.1.1 Transmitter

In the case that the lower sub-band at 450 - 451 MHz is used for receive by portable or mobile devices, there is potential interference from UE's transmitting in the LTE 450 band. We note, however, that there is no regulatory requirement specified for out-of-band transmissions from the LTE 450 band. Therefore, as a working assumption, we propose that the standard 3GPP requirements on UE emissions (ACLR and general SEM) are sufficient for the UE operating in the LTE 450 band. We further propose that power class 3 is appropriate for such a UE.

Proposal 1: The LTE 450 UE should be a power class 3 device with 23 dBm maximum output power.
The tolerance is [+2]/[-2] pending investigation of the UE PA and duplexer.

Proposal 2: The conventional 3GPP requirements on UE emissions (ACLR, general SEM, and spurious emissions) are suitable for the UE operating in the LTE 450 band. No additional requirements are imposed to offer protection to services operating in adjacent or nearby spectrum.

7.1.1.2 Receiver

The UE receive side is potentially more challenging. In the case that there is SARC operation in the upper sub-band at 460 - 461 MHz with portable or mobile device transmission, the impact to the UE receiver at 460 - 461 MHz must be considered. We first consider the out-of-band emissions from the SARC mobile station transmitter. The regulations indicate that the level of harmonics and spurious emissions must be attenuated by at least 60 dB compared to the fundamental. The maximum output power of the mobile SARC transmitter is no higher than 20 watts as limited by the regulations. Conducting the MCL analysis with this upper bound, the emissions due to the ACLR from the SARC mobile station can greatly increase the noise floor of the UE receiver operating in the LTE 450 MHz band depending on the physical separation between devices. For example, at a physical separation of 100 meters, the noise rise in the receiver in the adjacent channel can still be as high as 14.5 dB assuming free space path loss.

However, since the bandwidth of the SARC transmission signal is narrow (25 kHz), it can be expected that the emissions will decay quickly as the frequency separation is increased. That is, if the LTE channel is shifted to provide offset to the SARC transmit channel, the impact due to emissions falling in-band can be reduced. The amount of offset needed for a given MCL and in-band noise rise requires further study and understanding of the emission characteristics of the SARC transmitter beyond that which is available in the regulations. This would require a non-trivial study of emission characteristics for these systems. Furthermore, increasing the frequency separation by shifting the location of the LTE450 channel may have other detrimental impacts, such as self-desense, which may make this possibility undesirable from a deployment perspective.

The other aspect to consider is the UE receiver blocking. The 3GPP ACS and in-band blocking specifications provide guidance to the minimum guaranteed performance from the UE. For both of these specifications, a certain degradation to reference sensitivity is allowed in the presence of a jammer; for example, 14 dB reference sensitivity degradation is allowed for ACS case 1 and 6 dB degradation is allowed for in-band blocking. Even with the allowed degradation, the MCL is required to be very large to comply with standard UE receiver blocking requirements. The dominant interference cases appear to be ACS case 1 and in-band blocking. For example, at a physical separation of 100 meters, an additional 28 to 33 dB of coupling loss is required to meet the minimum performance requirement. For these cases, further frequency separation between the SARC transmitter and the LTE 450 UE receiver may not be as beneficial since the range of available frequency separation is limited by the 7 MHz passband and further limited by the objective to place a 5 MHz channel in the band. Thus, receiver blocking may be the dominant factor even if the ACLR noise from the SARC transmitter can be mitigated by frequency separation.

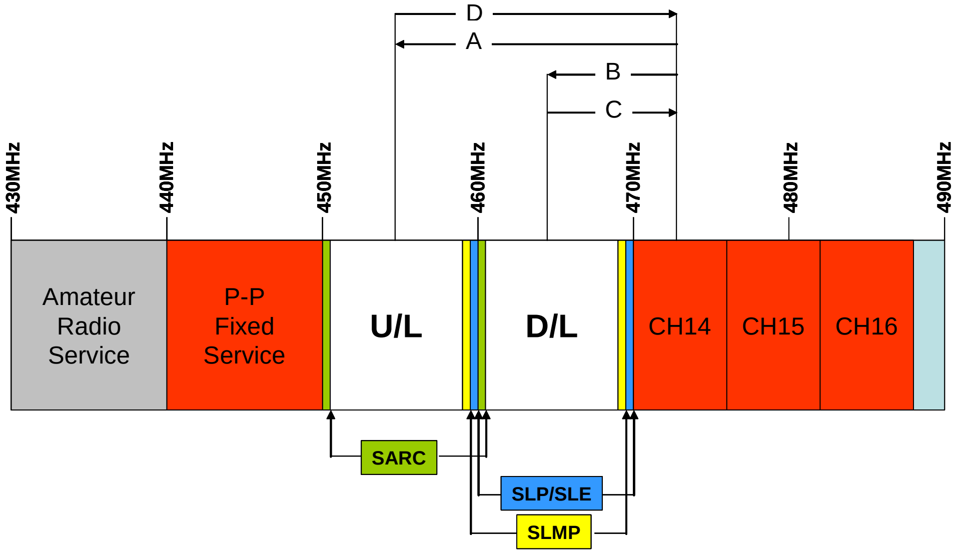
In addition to the blocking effect of the SARC transmitter located at 460 - 461 MHz, there is an impact due to intermodulation between the LTE 450 transmission and this jammer in the duplex gap. The 3rd order intermodulation term between the two is likely to fall within the receive band and desense the receiver. Note that the power levels which may be possibly observed here are much higher than those specified for the intermodulation requirement in the UE specification.

From the above discussion, it is apparent that a conventional worst-case deterministic analysis leads to results which are not able to be met by the UE and are therefore of limited value. An alternative approach could be to consider a statistical analysis where the characteristics of the aggressor and victim systems are taken into account. For example, the SARC system is predominantly used for electronic news gathering (ENG) type services where it is expected that the setup and usage of the system in any particular area is temporary. Furthermore, the ENG mobile transmitters are generally mounted on vans with a telescoping antenna aimed to a distant receiver and may not necessarily be transmitting at the maximum power allowed by the regulations. Thus, the probability of interference is greatly reduced since the events occur infrequently on a temporary basis in a localized area, the antenna is mounted on a tall mast, and the pattern is highly directional. Furthermore, in the case that there is severe interference, the network may be able handoff the UE to another frequency band if it is available, or may simply be able to accept the risk of outage to a subset of UE's in adverse radio conditions. If such considerations were to be taken into account, it is easy to see that the overall impact to the LTE network is much less severe than the deterministic worst-case analysis might suggest. The challenge in conducting such a statistical analysis, however, is to ability to gather the appropriate information regarding the operational parameters to construct a network simulation. In any event, it is expected that the receiver noise rise, intermod, and blocking challenges cannot be resolved by adjusting the receiver specifications, but rather by network deployment, handoff when available, and/or by accepting the risk of temporary outage for a subset of UE's subjected to strong interference.

Proposal 3: 3GPP UE receiver specifications will not be adjusted to specifically address the receiver coexistence with services in adjacent bands (SARC, SLP/SLE, SLMP).

7.1.1.3 UE coexistence with UHF TV broadcast

UE coexistence with UHF broadcast TV merits consideration due to the close frequency proximity between the two services. As indicated in [12], there are four possible interference scenarios to evaluate associated with TV interfering with LTE service and vice versa, with respect to the basestation and to the UE. This can be visualized in Figure 7.1.1.3-1 from [12], which is copied below for convenience.



SARC – Serviço Auxiliar de Radiodifusão e Correlatos (*Broadcast Ancillary Service*)
SLP – Serviço Limitado Privado (*Private Limited Service*)
SLMP – Serviço Limitado Móvel Privativo (*Private Mobile Limited Service*)
SLE – Serviço Limitado Especializado (*Specialized Limited Service*)

Figure 7.1.1.3-1: Adjacent Services to the LTE alloted band in 450 MHz band where U/L is the LTE uplink band and the D/L is the LTE downlink band

It can be seen in the figure that the closest TV channel is only 2 MHz separated from the upper edge of the downlink band for LTE 450. The next channel is separated by 8 MHz.

We consider three aspects in this analysis. First, we consider the emissions from the UE transmitting in the uplink for the LTE 450 band falling into the TV band and potentially disrupting TV reception. Second, we consider the out-of-band emissions from the TV broadcast falling into the downlink of the LTE 450 band. Lastly, we consider the blocking effect of the TV broadcast on the LTE 450 receiver.

7.1.1.3.1 UE emissions

The first aspect to consider is the UE unwanted emissions falling into the TV band. To determine this value, there are many methods of analyses which can be performed. Rather than reinventing the wheel, we instead refer to the extensive studies which were performed to address a similar concern of interference to TV reception at 700 MHz for Band 28 and Band 44. In that case, the studies were done within the Asia Pacific Telecommunity in the APT Wireless Group with participation from device vendors, infra-structure vendors, TV receiver manufacturers, government regulators, network operators, and others. The conclusion of this study [13], by consensus, was a recommendation that the UE emissions should be limited to -34 dBm/MHz over the TV band, scaled to the TV bandwidth. This level of protection was concluded to be appropriate to protect TV reception also considering the technical and economic factors associated with UE equipment. Subsequently, 3GPP adopted this recommendation in setting the UE emission requirements to -26.2 dBm/6 MHz and -25 dBm/8 MHz for Band 28 and Band 44, respectively.

However, we note that the propogation characteristics at 700 MHz differ from those at 450 MHz by approximately 3.8dB. Therefore, we revise the limit in order to maintain the same level of interference at the TV receiver as derived from the APT study for the same separation distance. Performing this adjustment, the emission level becomes -30 dBm/6 MHz.

Having established the target emission level required to protect broadcast TV reception, we must ensure that the LTE 450 UE is able to comply and define restrictions in transmit power and/or uplink allocation if needed. For the LTE 450 band, we are considering channel bandwidths of up to 5 MHz with uplink in the range from 451 – 458 MHz. While the exact frequencies for the band have not yet been agreed, it can be seen that there is at least 12 MHz separation from the edge of the uplink channel to the closest TV channel. For a 5 MHz channel bandwidth, at this separation, the emissions are governed by the spurious domain where the limit in accordance with the ITU-R recommendation is -36 dBm/100 kHz. Scaling this value yields an emission limit of -18 dBm/6 MHz. Thus, in order to comply with the target emission limit of -30 dBm/6 MHz, the UE duplexing filter must provide at least 12 dB rejection at this offset. Fortunately, we expect that the UE filter can readily provide this level of rejection.

7.1.1.3.2 TV broadcast emissions

The second aspect to consider is the out-of-band emissions from the TV broadcast falling into the LTE 450 UE receive band. The regulatory limits for digital broadcast TV are summarized in Table 3 of [12] and illustrated in Figure 7.1.1.3-2, copied here for convenience, for the worst case scenario of non-critical mask with class A transmission power (8 kW ERP) located in the nearest TV channel. Interpreting the points on this curve as ERP levels per 6 MHz, the noise profile is estimated pointwise from the curve as shown in the table below.

Frequency (MHz)	TV OOBE ERP (dBm/6 MHz)
467.5	9
466.5	1
465.5	-8
464.5	-12
463.5	-14

The averaged value of noise within the downlink from 463 – 468 MHz is approximately -5 dBm/MHz at the TV broadcast antenna.

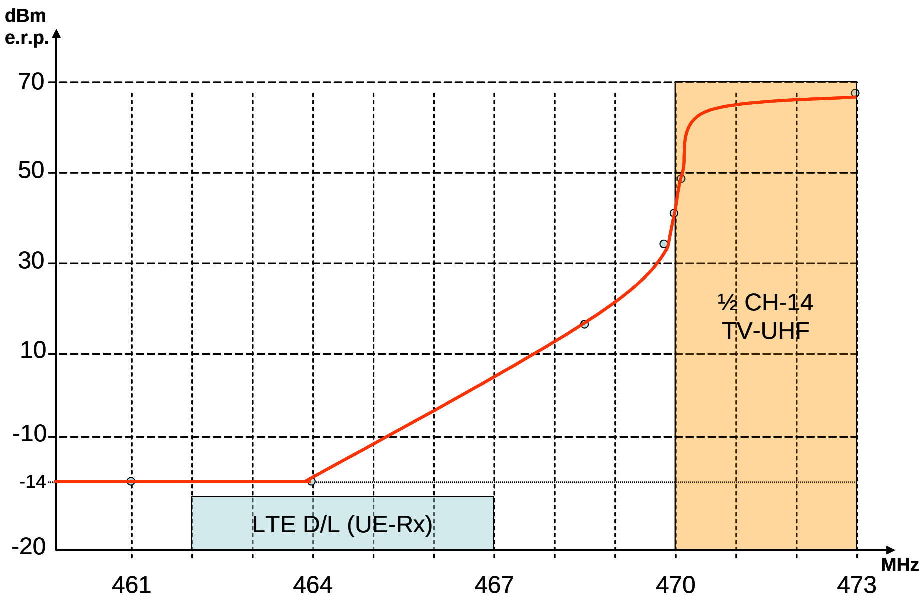


Figure 7.1.1.3-2: Class A DTV station transmission mask

To limit the degradation of reference sensitivity to 3dB, the required isolation is approximately 100 dB, disregarding antenna gain and hand and head loss. According to the path loss propogation model presented in [12] derived from ITU-R recommendation P-1546-1, the required separation distance from the UE to the TV broadcast tower is approximately 1 km.

In practice, emissions from TV broadcasters can be much better than the regulations require. Specifically, it may be possible to install sharper transmit filters at the broadcast station to further reduce the out-of-band emissions. In such a case, the minimum separation distance can be reduced.

7.1.1.3.3 UE blocking

The last aspect to consider is the impact of UE blocking due to the high power TV broadcast in the adjacent channel. It can be seen in Figure 7.1.1.3-3 that the pertinent parameters to consider are the ACS and in-band blocking when evaluating the impact of the two nearest TV channels.

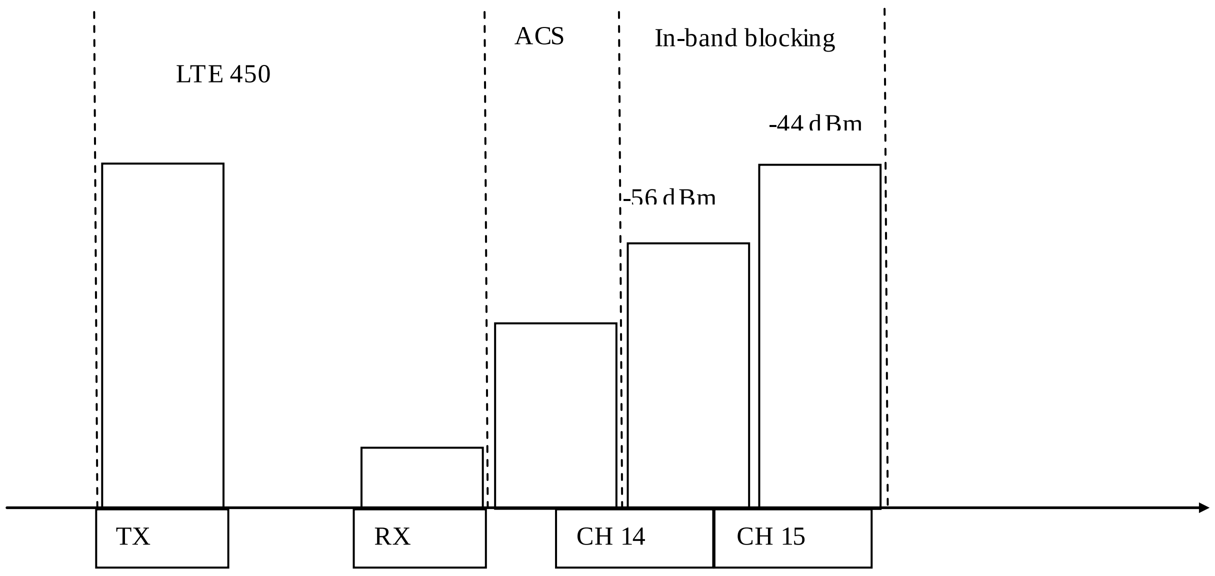


Figure 7.1.1.3-3: Relationship of TV channels to LTE 450 Rx band

For the same scenario as described above, with 100 dB isolation, the power received at the UE is approximately -31 dBm. According to the UE minimum performance specification for adjacent channel selectivity, the UE will be highly desensed in the presence of such a strong interfering signal. Thus, it is the UE ACS and blocking rather than the TV broadcast out-of-band emissions that is likely to be the limiting factor in determining UE performance in the presence of Channel 14 broadcast. This is especially true if the out-of-band emissions from the TV broadcast outperform the regulatory mask. The case 2 ACS specification indicates that a UE which receives an adjacent interfering signal as high as -25 dBm requires the desired LTE signal to be received at -56.5 dBm, which is approximately 40 dB above reference sensitivity. For case 1 ACS, the interfering signal may be tolerated at a level of approximately -51 dBm with a desense of 14 dB. In this case, the additional isolation required is 20 dB resulting in a path of 6.6 km.

For the blocking interference from Channel 15 broadcast, it is anticipated that the UE Rx filter will be able to provide rejection. Initial feedback from a filter vendor suggests that 15 - 25 dB rejection is available when averaged over Channel 15. Furthermore, the Channel 15 broadcast is in the region between case 1 and case 2 in-band blocking where the tolerance to interference is much higher than ACS. In this case, the separation can be reduced to less than 1 km depending on the filter performance. Greater than 40 dB filter attenuation is expected for Channel 16, so this channel can be disregarded.

For specific installations such as CPE with rooftop-mounted antennas, the minimum separation distance may be larger as shown in [12]. For those cases, the rooftop mounted antenna may be able to provide significant antenna gain (8 dBi) and if evaluated against the in-band blocking case 1 requirement of -56 dBm, the required separation was reported to be 27.4 km. However, in these cases, the antenna is in a fixed location and is directional, so interference mitigation can be more easily achieved by exploiting directionality. Additional filtering may also be possible on an external rooftop mount.

The problem of UE blocking can be partially mitigated by several methods. The first is to assume that actual UE devices will have better ACS and blocking performance than dictated by the minimum performance specification. Indeed, this may be the case, especially under nominal conditions, though it cannot be guaranteed. However, these are implementation-specific aspects which are outside of the scope of 3GPP. A second approach is to rely on attenuation from the Rx filter in the UE. In the worst case, the filter can not guarantee any attenuation at 2 MHz offset. Thus, attenuation of a TV signal on Channel 14 cannot be guaranteed. However, meaningful attenuation can be achieved in Channel 15 and beyond. Lastly, exclusion zones and increased basestation deployment in locations of strong Channel 14 interference may be an option in specific deployment scenarios to improve the signal-to-inteference ratio.

We note that the situation described here bears similarity to other scenarios previously considered in 3GPP. For example, in the US 700 MHz bands a high power DTV broadcast centered at 725 MHz is potentially an interfering signal to the downlink of Bands 12 and 17. For the case of Band 12, the edge-to-edge separation is 1 MHz which is similar to the situation here. The solution for Band 12 was to rely upon deployment techniques, exclusion zones, and to accept the risk of interference and outage under worst case conditions rather than to specify an ACS requirement on the UE. Such a requirement would have been inconsistent with the Rx linearity requirement for any other band and so it was concluded that other deployment techniques to address the problem would be preferable. For Band 17, an increased separation is available so that the UE filter can provide attenuation. This is similar to the Channel 15 scenario described here. As another example, in Europe, the uppermost TV broadcast channel extends to 790 MHz, which is also only 1 MHz separated from the downlink of Band 20, yet there is no explicit additional UE blocking requirement since the problem is addressed otherwise in deployment.

7.1.1.3.4 Proposal

We propose that no supplementary specifications for emissions, ACS, or blocking be defined for the LTE 450 UE to address coexistence with UHF TV broadcast. The analysis in this paper has shown that UE emissions into the TV band will be well controlled and that out-of-band and blocking interference from adjacent TV channel 14 may require specific site deployment solutions and/or that the operator accept an increased risk of outage in worst case conditions. Adding requirements to the specification that can be met with existing state-of-the-art technology will not change this situation since the worst case can be quite severe. On the other hand, adding new requirements which do not fully address the coexistence condition in the worst case may also imply that additional site solutions or other techniques are not needed. We note that a similar approach has been adopted for other bands with similar circumstances. Therefore, in light of the timeline and obligation for deployment of this Band for LTE in Brazil, the limited value that additional requirements would provide, and the possibility of misinterpretation of adding new requirements which do not fully resolve the worst case coexistence condition, we propose that no new requirements be specified by 3GPP for the purpose of UE coexistence with TV and that in the case that problems are experienced, that they be resolved by site specific deployment solutions.

7.1.2 BS aspects

7.1.2.1 BS Coexistence with TV system

The lower edge of UHF-TV band is 2MHz above the DL band and 12 MHz above the UL band. The following interference scenarios which may impact BS requirements are considered:

- ATV Transmitter → LTE BS Receiver (Blocking)
- DTV Transmitter → LTE BS Receiver (Blocking)
- LTE BS OOBE → TV Receiver

The analysis on LTE450 BS coexistence with TV system is presented in Annex A.1. From the investigation we can find that:

The rejection from LTE450 towards its own DL, may help for co-existence between UHF-TV and LTE450, assuming a large rejection (about 90dB) from LTE450 UL to LTE450 DL. No additional blocking requirement is proposed for BS receiver.

Physical separation is required between the BS and the TV receiver to avoid interference. The distance is dependent on the attenuation from the BS duplexer. Since currently there is no regulatory requirement on OOBE for LTE BS coexistence with TV system, it is proposed not to define additional emission requirements for BS transmitter in 3GPP specification.

7.1.2.2 BS Coexistence with SARC system

Within 450~470 MHz, SARC service can work in the range of 450~451 MHz or 460~461 MHz, which is adjacent to the low edge of LTE 450 band, and duplexer direction is not specified. The following interference scenarios need to be considered:

- SARC OOBE → LTE BS Receiver
- SARC TX Power → LTE BS Receiver (Blocking)
- LTE BS OOBE → SARC receiver

According to Clause 5.2, no receiver requirements such as blocking or adjacent channel rejection requirements are mandated for SARC systems. To perform the interference analysis from LTE BS to SARC systems receiver, some assumptions for SARC systems such as noise figure and allowed desensitization are made.

7.1.2.2.1 SARC OOBE → LTE BS Receiver

The interference analysis for SARC OOBE to LTE450 BS receiver is shown in table 7.1.2.2-1. The allowed interference power in LTE RX channel is -108 dBm/5MHz with 1 dB desense. According to clause 5.2 in, the spurious attenuation of SARC service is 60 dBc, using 25 kHz channel as example, the accumulated emission power in 5 MHz is 6 dBm. Hence required connector to connector coupling loss is 114 dB.

Table 7.1.2.2-1: Interference analysis for SARC OOBE to LTE450 BS

Item description	Unit	Value	Comment
Required SARC SEM power in RX channel with 1dB sensitivity degradation：	dBm/5MHz	-108	
SARC maximum transmitted power	dBm	43	
Spurious attenuation relative to the fundamental	dBc	60	
SEM power of SARC carrier @25 kHz	dBm	-17	
SEM power of SARC carrier @5 MHz	dBm	6	
Required connector to connector coupling loss	dB	114	

7.1.2.2.2 SARC TX Power → LTE BS Receiver (Blocking)

The blocking analysis for SARC transmit power to LTE450 BS is shown in table 7.1.2.2-2. The narrow-band blocking requirement for LTE is -49 dBm for 6 dB desense and -60 dBm for 1 dB desense. The maximum SARC transmit power is 43 dBm. Hence the required coupling loss is 103 dB for protection of BS blocking.

Table 7.1.2.2-2: Interference analysis for SARC power to LTE450 BS

Item description	Unit	Value	Comment
SARC transmit power	W	20	
SARC transmit power	dBm	43	
LTE narrow-band blocking requirement（6dB desense）	dBm	-49	
LTE narrow-band blocking requirement（1dB desense）	dBm	-60	
Required connector to connector coupling loss	dB	103	

7.1.2.2.3 LTE OOBE → SARC receiver

The interference analysis for LTE OOBE to SARC receiver is shown in table 7.1.2.2-3. Assuming noise figure of SARC equals to 5 dB, the allowed interference power is -131 dBm/25kHz for 1 dB desense. Using LTE ACLR = 45 dBc, the LTE BS emission within 25 kHz is -25 dBm. Then the rrequired connector to connector coupling loss is 106 dB.

Table 7.1.2.2-3: Interference analysis for LTE450 BS OOBE to SARC receiver

Item description	Unit	Value	Comment
Noise figure of SARC receiver	dB	5	
Allowed desense	dB	1	
Allowed interference level in SARC receiver	dBm/25 kHz	-131	
LTE450 BS maximum transmitted power	dBm	43	
LTE450 BS ACLR	dBc	45	
BS unwanted emission	dBm/25 kHz	-25 dBm	
Required connector to connector coupling loss	dB	106	

7.1.2.2.3 Conclusion

For SARC operated in the frequency range of 450-451MHz, thanks to the isolation of LTE BS duplexer, the LTE OOBE to SARC receiver can be reduced significantly and the coexistence is achievable for practical deployment. While the sub-band is just adjacent to LTE450 UL band and there is no guard band, the interference from SARC transmitter to LTE450 BS receiver needs further consideration in deployment.

For SARC operated in the frequency range of 460-461MHz, which is at least 2 MHz from LTE450 BS receiver, the BS may provide some additional attenuation and reduce the blocking power from SARC service. While the sub-band is just adjacent to LTE450 DL band and there is no guard band, some mitigation techniques such as distance separation and site engineering are needed to provide needed isolation for the case LTE BS interference to SARC service.

Due to the SARC systems are point-to-point services with highly directional antenna and are distributed rarely, it is expected that the co-existence between SARC systems and LTE450 can be achieved by deployment and coordination methods. Therefore, it is proposed that no additional requirement to be defined for BS transmitter and BS receiver to address the coexistence with SARC service.

7.1.2.3 BS Coexistence with the limited services (SLMP, SLP, SLE)

The limited services (SLMP, SLP, SLE) are operating in 458 – 460 MHz for downlink and 468 – 470 MHz for uplink, which is adjacent to LTE450 band. The following interference scenarios need to be considered:

- Limited service BS OOBE → LTE BS Receiver
- Limited service BS transmitter → LTE BS Receiver (Blocking)
- LTE BS OOBE → Limited service BS Receiver
- Limited service terminal OOBE → LTE BS Receiver
- Limited service terminal transmitter → LTE BS Receiver (Blocking)
- LTE OOBE → Limited service terminal Receiver

According to Clause 5.3 in [5], no receiver requirements such as blocking or adjacent channel rejection requirements are mandated for the limited service. To perform the interference analysis from LTE BS to the limited service receiver, some assumptions for the limited service such as noise figure and allowed desensitization are made.

7.1.2.3.1 Limited service BS OOBE → LTE BS Receiver

The BS emission interference from the limited services to LTE BS receiver is shown in Table 7.1.2.3-1. The allowed interference power in LTE RX channel is -108 dBm/5MHz with 1 dB desense. According to ANATEL regulation 554, the emission attenuation is 70 dBc, and then the accumulated emission power within 5 MHz is 10 dBm. The required connector to connector coupling loss is 118 dB.

Table 7.1.2.3-1: Interference analysis for limited service BS emission to LTE450 BS

Item description	Unit	Value	Comment
Allowed interference power in RX channel with 1dB sensitivity degradation：	dBm/5MHz	-108	
Limited service maximum transmitted power	dBm	54	
Spurious attenuation relative to the fundamental	dBc	70	
SEM power of limited service carrier @12.5 kHz	dBm	-16	
SEM power of limited service carrier @5 MHz	dBm	10	
Required connector to connector coupling loss	dB	118	
Attenuation of the transmit filter in limited service BS	dB	90	
Required coupling loss considering the attenuation of the transmit filter	dB	28	

7.1.2.3.2 Limited service BS Tx Power → LTE BS Receiver (Blocking)

The blocking analysis for the limited service transmitter to LTE450 BS is shown in table 7.1.2.3-2. The narrow-band blocking requirement for LTE is -49 dBm for 6 dB desense and -60 dBm for 1 dB desense. The maximum transmit power of the limited service is 54 dBm. If the BS duplexer rejects its own transmitted signal by 90dB, 114-90=24 dB coupling loss is needed.

Table 7.1.2.3-2: Interference analysis for limited service BS power to LTE450 BS

Item description	Unit	Value	Comment
Limited service transmit power	W	250	
Limited service transmit power	dBm	54	
LTE narrow-band blocking requirement（6dB desense）	dBm	-49	
LTE narrow-band blocking requirement（1dB desense）	dBm	-60	
Attenuation of duplexer	dB	90	
Required connector to connector coupling loss	dB	24	

7.1.2.3.3 LTE BS OOBE → Limited service BS Receiver

The interference analysis for LTE OOBE to limited service receiver is shown in table 7.1.2.3-3. Assuming noise figure of the limited service BS receiver is equal to 5 dB (we assume the same as for LTE BS), the allowed interference power is -134 dBm/12.5kHz for 1 dB desense. Using LTE ACLR = 45 dBc, the LTE BS emission within 12.5 kHz is -28 dBm, and then required connector to connector coupling loss is 106 dB. The uplink frequency of the limited service is in the region of transition between LTE450 TX and RX, the duplexer can provide some attenuation which will help for co-existence in some degree for LTE450 BS OOBE to limited service receiver.

Table 7.1.2.3-3: Interference analysis for LTE450 BS OOBE to limited service receiver

Item description	Unit	Value	Comment
Noise figure of limited service receiver	dB	5	
Allowed desense	dB	1	
Allowed interference level in limited service receiver	dBm/12.5 kHz	-134	
LTE450 BS maximum transmitted power	dBm	43	
LTE450 BS ACLR	dBc	45	
BS unwanted emission	dBm/12.5 kHz	-28 dBm	
Required connector to connector coupling loss	dB	106	

7.1.2.3.4 Limited service terminal OOBE → LTE BS Receiver

The UE emission interference from the limited services to LTE BS receiver is shown in Table 7.1.2.3-4. The allowed interference power in LTE RX channel is -108 dBm/5MHz with 1 dB desense. According to ANATEL regulation 554, the emission attenuation is 64 dBc, and then the accumulated emission power within 5 MHz is 6 dBm. Hence the required connector to connector coupling loss is 114 dB.

Table 7.1.2.3-4: Interference analysis for limited service terminal emission to LTE450 BS

Item description	Unit	Value	Comment
Required limited service SEM power in RX channel with 1dB sensitivity degradation :	dBm/5MHz	-108	
Limited service maximum transmitted power	dBm	44	
Spurious attenuation relative to the fundamental	dBc	64	
SEM power of limited service carrier @12.5 kHz	dBm	-20	
SEM power of limited service carrier @5 MHz	dBm	6	
Required connector to connector	dB	114	

7.1.2.3.5 Limited service terminal Tx Power → LTE BS Receiver (Blocking)

The blocking analysis for the limited service terminal transmitter to LTE450 BS is shown in table 7.1.2.3-5. The narrow-band blocking requirement for LTE is -49 dBm for 6 dB desense and -60 dBm for 1 dB desense. The maximum transmit power of limited service terminal is 44 dBm. Hence the required connector to connector coupling loss is 104 dB.

Table 7.1.2.3-5: Interference analysis for Limited service terminal power to LTE450 BS

Item description	Unit	Value	Comment
Limited service transmit power	W	25	
Limited service transmit power	dBm	44	
LTE narrow-band blocking requirement（6dB desense）	dBm	-49	
LTE narrow-band blocking requirement（1dB desense）	dBm	-60	
Required connector to connector coupling loss	dB	104	

7.1.2.3.6 LTE OOBE → Limited service terminal Receiver

The emission interference from LTE BS to the receiver of the limited services terminal is shown in Table 7.1.2.3-6. Assuming the NF of the limited service is equal to 7 dB, the allowed interference power in LTE RX channel is -126dBm/12.5 kHz with 3 dB desense. Using LTE ACLR = 45 dBc, the LTE BS emission within 12.5 kHz is -28 dBm. The required connector to connector coupling loss is 98 dB.

Table 7.1.2.3-6: Interference analysis for LTE450 BS OOBE to Limited service receiver

Item description	Unit	Value	Comment
Noise figure of Limited service receiver	dB	7	
Allowed desense	dB	3	
Allowed interference level in Limited service receiver	dBm/12.5 kHz	-126	
LTE450 BS maximum transmitted power	dBm	43	
LTE450 BS ACLR	dBc	45	
BS unwanted emission	dBm/12.5 kHz	-28 dBm	
Required connector to connector coupling loss	dB	98	

7.1.2.3.7 Conclusion

From the investigation above, for LTE BS transmitter, the uplink frequency of the limited service is in the region of transition between LTE TX and RX, and the duplexer may provide some attenuation. While the downlink band of LTE450 is just adjacent to the downlink band of the limited service, the BS transmitter may cause potential interference to the terminal receiver of the limited service. However, since there is no regulatory requirement on unwanted emission for LTE BS coexistence with the limited service, it is proposed not to define additional emission requirements for BS transmitter in 3GPP specification. For LTE BS receiver, the attenuation of duplexer may help for co-existence. While the uplink band of LTE450 is just adjacent to the uplink band of the limited service, the terminal of the limited service may cause potential interference to the LTE450 BS receiver. Some mitigation techniques such as site engineering may be used to alleviate coexistence.

7.2 Frequency band arrangement

7.2.1 Consideration on BS implementation

7.2.1.1 Inter-modulation

According the band allocation in Brazil, TX–RX frequency separation is 10MHz, which may be the smallest one among the current 3GPP bands. And it is important to consider the inter-modulation impact to the receiver from own TX. It is found that when the bandwidth of transmitted carrier(s) is 5MHz, 5th order inter-modulation other than 3rd order inter-modulation product will fallen into own receiver channel. To avoid IM3 interference, it is proposed that the bandwidth of transmitted carrier(s) is not larger than 5 MHz, i.e. some multi-carrier cases which may cause IM3 interference are not recommended, such as 3MHz+3MHz, 5MHz+1.4MHz.

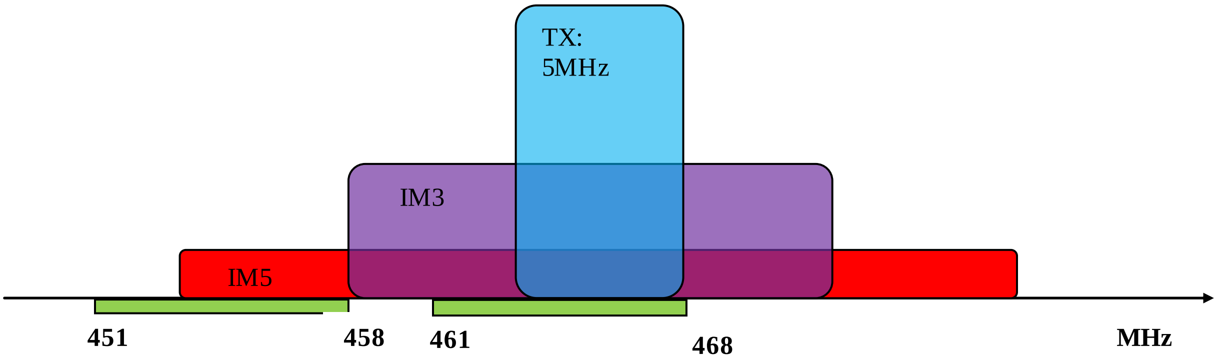


Figure 7.2.1-1: 3rd order and 5th order inter-modulation

7.2.1.2 BS duplexer

The narrow gap and high rejection are the main issues. All the filter characteristics shown are examples only and do not preclude other implementations.

A possible filter is shown in Figure 7.2.1-2, considering a 9 order cavity filter with 3000 un-loaded Q value, The BS TX filter is larger than 105 dB attenuation at the RX band.

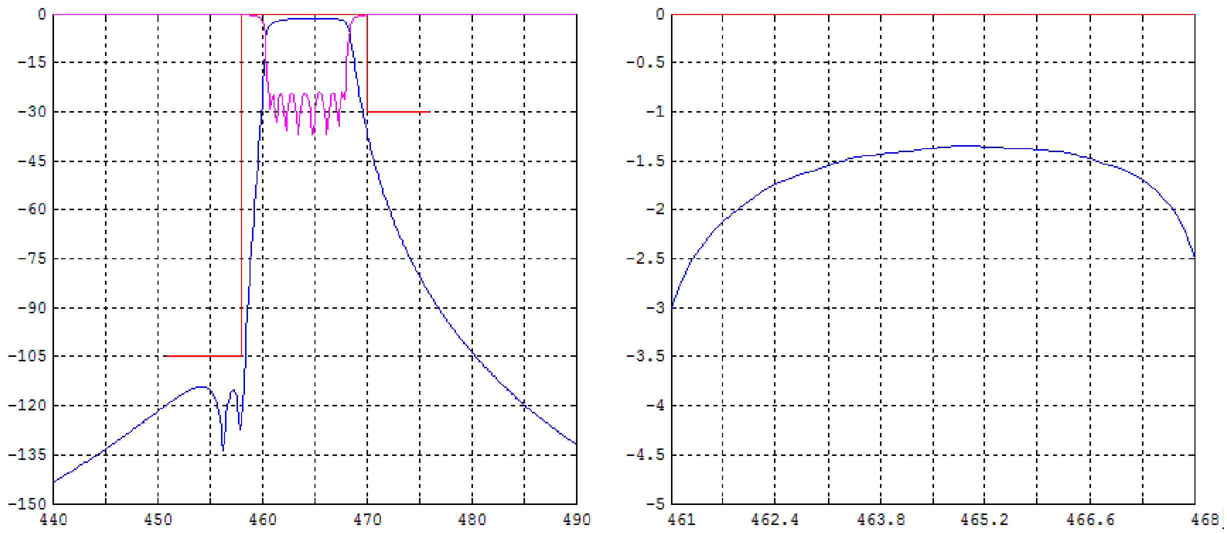


Figure 7.2.1-2: 9 order BS TX filter evaluation

Taking into account the temperature and manufacturing margin, the insertion loss at 461 MHz is about 3.3 dB, and the insertion loss at 468 MHz is about 2.7 dB. The large insertion loss in the edge will cause heat sink problem and need larger size.

For the Rx to Tx rejection, considering the output power is 43 dBm, and the blocking requirement for LTE is -43 dBm, then the rejection requirement for the Rx filter is at least 86 dB. In the simulation, 90dB limit is assumed. Considering a 9 order cavity filter with 3000 un-loaded Q value, Figure 7.2.1-3 gives the evaluation of the BS RX filter.

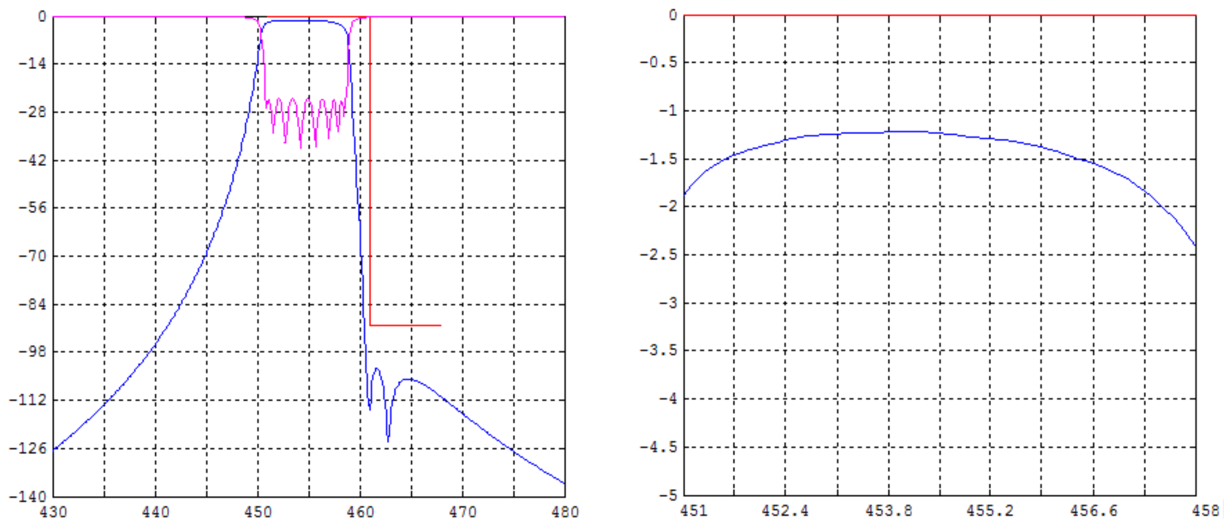


Figure 7.2.1-3: 9 order BS Rx filter evaluation

Taking into account the temperature and manufacturing margin, the insertion loss at 451 MHz is about 2.2 dB, and the insertion loss at 458 MHz is about 2.7 dB. The large insertion loss in the edge will cause sensitivity degradation.

7.2.2 Band arrangement

ITU has identified 10 recommended frequency arrangements to implement the IMT systems in the frequency range 450-470 MHz as shown in Table 7.2.2-1. Following the ITU and CITEL recommendations [15], the arrangement of D10 is being considered in Brazil.

Table 7.2.2-1: Frequency arrangements in the band 450-470 MHz

Frequency arrangements	Paired arrangements				Un-paired arrangements (e.g. for TDD) (MHz)
	Mobile station transmitter (MHz)	Centre gap (MHz)	Base station transmitter (MHz)	Duplex separation (MHz)	
D1	450.000-454.800	5.2	460.000-464.800	10	None
D2	451.325-455.725	5.6	461.325-465.725	10	None
D3	452.000-456.475	5.525	462.000-466.475	10	None
D4	452.500-457.475	5.025	462.500-467.475	10	None
D5	453.000-457.500	5.5	463.000-467.500	10	None
D6	455.250-459.975	5.275	465.250-469.975	10	None
D7	450.000-457.500	5.0	462.500-470.000	12.5	None
D8					450-470 TDD
D9	450.000-455.000	10.0	465.000-470.000	15	457.500-462.500 TDD
D10	451.000-458.000	3.0	461.000-468.000	10	None

The CDMA technologies have been deployed in the 450MHz bands. Within the frequency range of 451~468 MHz, there are 4 sub-bands defined in the CDMA band class 5 which are sub-band A, B, H, and I [14]. Among those 4 sub-bands, sub-band A is currently being widely deployed in the world and more than 80% of CDMA450 networks worldwide adopted the CDMA450 sub-band A. CDMA450 sub-band A is consistent with ITU frequency arrangement D4 as described above.

The 450MHz bands offer the significant advantages of reduced propagation loss and improved indoor penetration due to its low frequency nature, which are highly valued by the spectrum owner and administrators. In order to maximize ecosystem for 450MHz band in Brazil, the band arrangement for LTE450 is proposed to be compatible with the existing CDMA450 sub-band A.

The 450-470 MHz would be a challengeable band comparing with existing bands. . From UE performance perspective, it is highly beneficial to restrict the transmit bandwidth as 5MHz or smaller. It was also shown in [16] that at least 5MHz duplex gap is desired. Band arrangement was also discussed in other contributions, such as [17]. Alternatives increasing the 10 MHz Tx/Rx duplex spacing can reduce the required Tx-Rx isolation and allow an increase in uplink RB allocation. However, it is incompatible with the CDMA450 sub-band A and inconsistent with the channelization provided in current regulations for this band in Brazil [3].

Based on the analysis above, the following band arrangement is adopted for LTE450 band in Brazil:

Table 7.2.2-1: E-UTRA frequency bands for Band [31]

E-UTRA Operating Band	Uplink (UL) operating band BS receive UE transmit	Downlink (DL) operating band BS transmit UE receive	Duplex Mode
	F_{UL_low} – F_{UL_high}	F_{DL_low} – F_{DL_high}	
[31]	452.5 MHz – 457.5 MHz	462.5 MHz – 467.5 MHz	FDD

8 Study of E-UTRA specific issues

8.1 UE duplexer

From [R12-WP5D-C-0290!!-E], following ITU and CITEL recommendations, the D10 frequency arrangement of Recommendation ITU-R M.1036-4 (451-458 MHz uplink, 461-468 MHz downlink) is being considered in Brazil as shown in Table 8.1-1.

Table 8.1-1: ITU-R D4 and D10 frequency arrangements in the band 450-470 MHz

Frequency arrangements	Mobile station transmitter (MHz)	Centre gap (MHz)	Base station transmitter (MHz)	Duplex separation (MHz)	Un-paired spectrum (e.g. for TDD) (MHz)
D4	452.500-457.475	5.025	462.500-467.475	10	None
D10	451.000-458.000	3	461.000-468.000	10	None

From [R4-132021], however, a modified D4 arrangement was proposed as a starting point for LTE450 operation in Brazil in order to specify the BS and UE requirements as shown below in Table 8.1-2

Table 8.1-2: LTE450 proposed band arrangement [R4-132021]

E-UTRA Operating Band	Uplink (UL) operating band BS receive / UE transmit	Downlink (DL) operating band BS transmit / UE receive	Duplex Mode
	F_{UL_low} – F_{UL_high}	F_{DL_low} – F_{DL_high}	
[31]	452.5 MHz – 457.5 MHz	462.5 MHz – 467.5 MHz	FDD

This proposed LTE450 band is similar but not identical to CDMA band class 5 sub-bands A which is based on ITU D4 band arrangements. Therefore, in our analysis, we have evaluated the performance of a CDMA band class 5 sub-band duplexer(s) in order to determine the expected duplexer performance which can be used to determine the RX and TX performance for LTE450 UE

8.1.1 CDMA band class 5 sub-band duplexer Performance Summary

In order to determine reasonable SAW duplexer performance parameters for use in further analysis data sheets from two 450MHz sub-band A SAW vendors were examined. The vendors are labelled A and B

Table 8.1-3: Duplexer TX-to-ANT Specifications

TX TO ANT			
		A	B
Insertion loss [dB]	Typical	2.6	2.2
	Worst case	3.8	3.2
TX rejection [dB]	Typical	56	60
	Worst case	40	40

Table 8.1-4: Duplexer ANT-to-RX Specifications

ANT TO RX			
		A	B
Insertion loss [dB]	Typical	3	2.9
	Worst case	4	3.7
RX rejection [dB]	Typical	54	62
	Worst case	47	48

Table 8.1-5: Duplexer TX-to-RX Rejection

TX TO RX			
		A	B
Rejection [dB]	Typical	55	65
	Worst case	42	54

The following figure shows a typical SAW duplexer frequency response. The recommended worst case TX-to-RX rejection is plotted for reference. This recommendation considers the temperature drift of typical SAW filters.

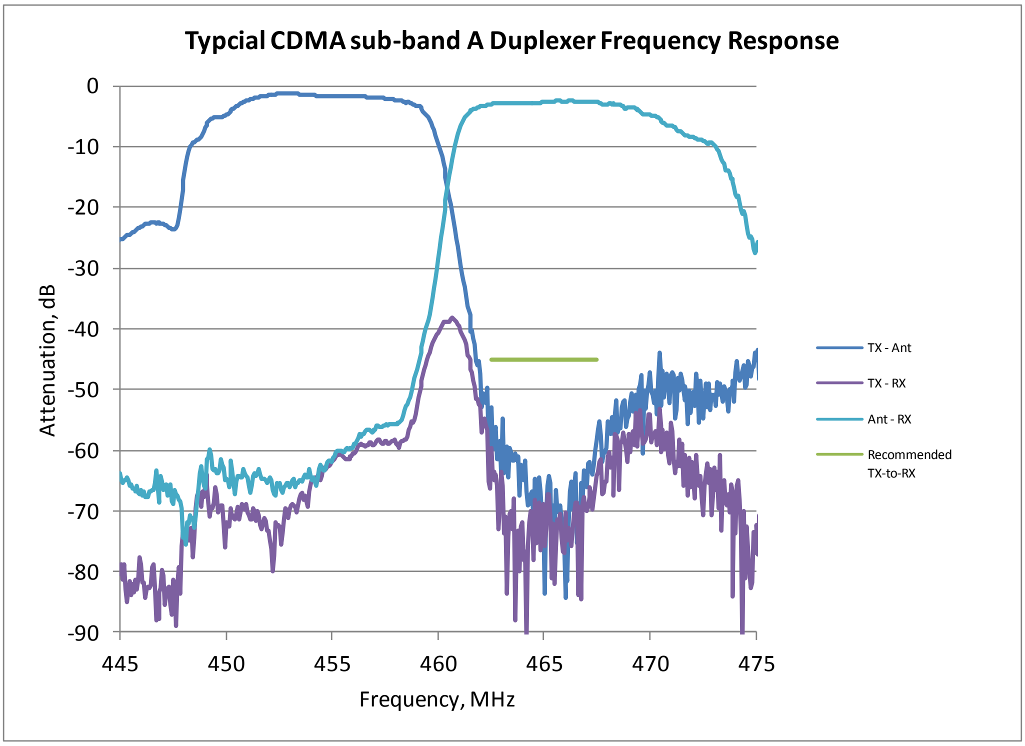


Figure 8-1: Typical Duplexer Frequency Response

NOTE: The requirements for RX sensitivity are based on R4-132787

8.2 UE transmitter requirements

8.3 UE receiver requirements

8.3.1 Self interference only aspects

The ITU/CITEL D10 frequency arrangement will be extremely challenging to provide the necessary TX-RX duplexer isolation so as to avoid receiver self interference due to the small duplex gap and reduced TX-RX spacing (10MHz).

In this clause we look at the impact of full RB and partial RB allocated to UL transmitter assuming the D10 frequency arrangement with two values of TX –RX isolation. In our analysis we considered the Tx/Rx configuration as shown in Figure 8.3.2-1below

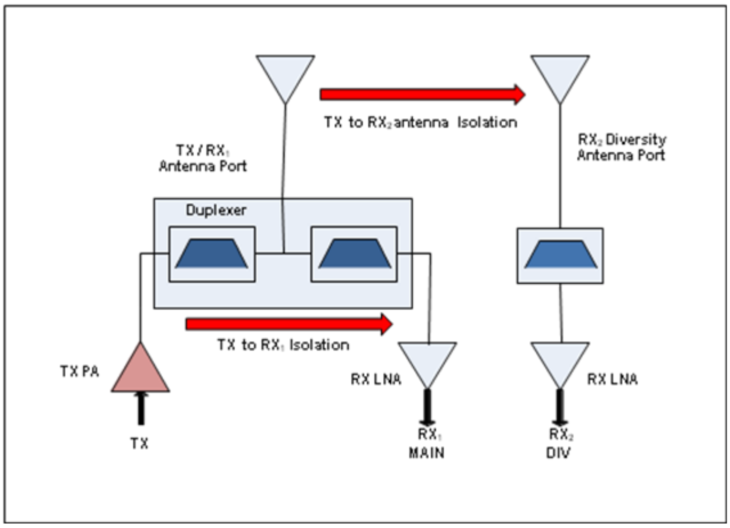


Figure 8.3.2-1: Tx – Rx configuration

Assumptions;

- Same maximum UL and DL channel bandwidth
- Full resource block (RB) allocation is being received in the DL as per RAN4 assumptions
- TX RB allocation starting from worst channel edge in the UL as per RAN4 assumptions
- TX – RX duplex spacing of 10MHz as per ITU D10 frequency arrangement
- UE is transmitting at maximum power (23 dBm)
- PA PSD simulation of spectrum assuming 33dB UTRA ACLR
- LO and Image of -28dBc
- Duplex filter TX to RX isolation of 50dB (handset –SAW filter) and 80dB (For large size CPE/WLL - Ceramic filter)
- Transmitter to diversity antenna port isolation of 6 dB (handset) and 10-15dB (CPE/ WLL)
- Desense is referenced to RX main antenna port only

a) Full RB allocation for 3MHz (maximum 15 RB) and 5MHz (maximum 25 RB) channel bandwidth

Figure 8.3.2-2 shows the TX–RX duplexer isolation needed for main receiver for the allowed maximum UL transmission configuration for 3/5MHz channel bandwidth.

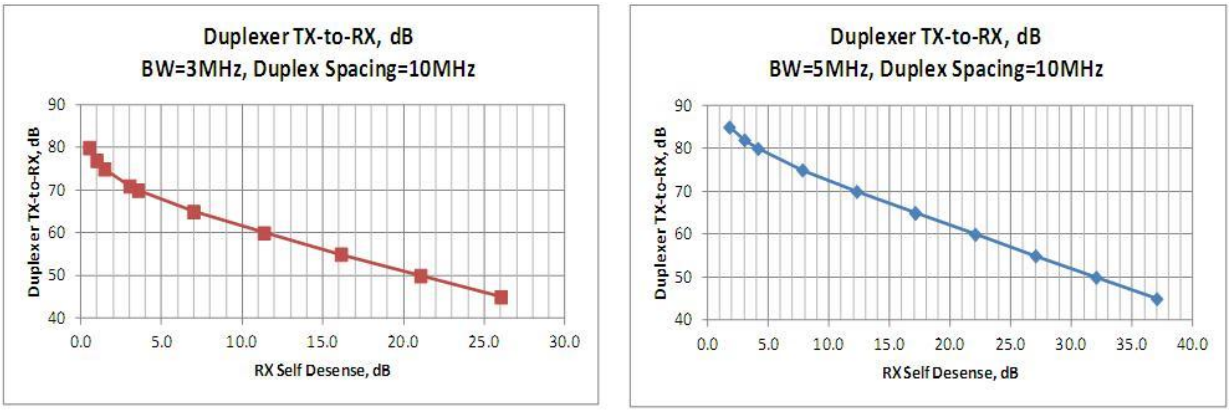


Figure 8.3.2-2: channel bandwidth / Duplex TX-RX isolation / Rx self desense

These results for the required TX -RX duplex isolation are summarized in Table 8.3.2-1 for the receiver 1dB and 3dB desense case

Table 8.3.2-1: TX -RX Duplex isolation

Channel bandwidth	Full RB allocation (RB)	Tx -Rx Duplex isolation for	
		1dB desense	3 dB desense
3MHz	15	78 dB	77 dB
5MHz	25	85 dB	82 dB

This analysis only considers the impact on the main RX_1 port. Results, taking into account the RX_2 diversity port, will be expected to be better, however, the improvement in a real deployment may be limited by the smaller isolation (6dB) for TX – RX_2 (diversity port) due to hand and body coupling. In the case of a fixed device or CPE/WLL deployment we could expect to see much larger isolation for the TX – RX_2 (diversity port) due to the larger form factor and lack of hand/body coupling effects.

Our studies have considered both a CDMA 450MHz sub-band A duplexer filter which can provide a 45-50dB of TX-RX isolation and a CDMA 450MHz ceramic duplexer filter which is able to offer an 80dB+ value of TX-RX isolation. The ceramic filter due to its larger size would be more applicable for a large size fixed CPE/ WLL type terminal implementation but has the benefit meeting the required TX-RX isolation needed to minimize self interference for full RB allocation.

Figure 8.3.2-3 shows the typical noise ingress assuming A CDMA sub-band A SAW duplex filter (50dB TX-RX isolation) and a ceramic duplexer (80dB of TX-RX isolation) for 3/5MHz channel bandwidth operation. The TX operation band is 452.5-457.5MHz and the RX band is 462.5-467.5MHz is shown below

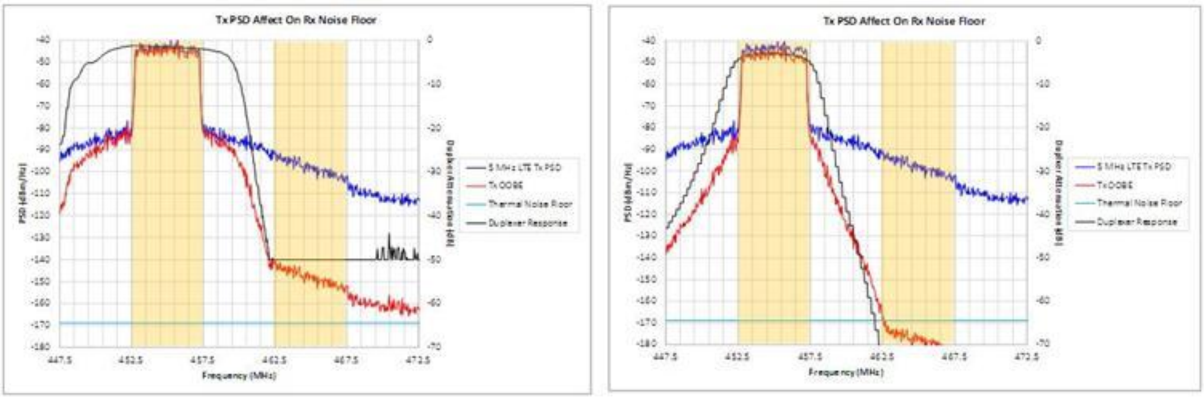


Figure 8.3.2-3: Example CMA 450 sub-band-A SAW and a Ceramic duplexer for 5MHz

b) Partial UL RB allocation for 3MHz and 5 MHz channel bandwidth operation

In the case of a SAW filter implementation, if the transmitted configuration is reduced by limiting the number of UL resource blocks (RB) then the TX noise and OOBE into the RX band will be expected to decrease.

Table 8.3.2-2 shows the large reduction in RB allocation needed to meet a 1dB desense criteria for the RX sensitivity assuming 50 dB of TX – RX duplex isolation for a TX- RX spacing of 10 MHz

Table 8.3.2-2: UL configuration for RFSENS with TX- RX spacing of 10 MHz

Channel bandwidth	Maximum UL (RB)	Partial UL RB allocation (RB) for 1 dB desense
3MHz	15	[6] RB
5MHz	25	[5] RB

This indicates that partial [5/6] RB allocation can be used to mitigate the effect of sub-optimum TX-RX isolation to limit the desense impact on the receiver sensitivity but would mean a reduction in the UL peak throughput at the cell edge for a SAW duplexer implementation

The above analysis is only focused on the self interference due to duplexer performance limitation. However, it is worth noting that there are other UE impairments such as IP2, phase noise reciprocal mixing, etc which need to be considered in deriving the UE receiver sensitivity.

9 Study of MSR specific issues

10 Channel numbering for E-UTRA, MSR

10.1 Channel bandwidths

For LTE450 band specification of radio requirements are considered for the bandwidths shown in Table 10.1-1

Table 10.1-1: E-UTRA channel bandwidth for FDD

E-UTRA band / channel bandwidth						
E-UTRA Band	**1.4 MHz**	**3 MHz**	**5 MHz**	**10 MHz**	**15 MHz**	**20 MHz**
…						
[31]	Yes	Yes	Yes	-	-	-

10.2 Carrier frequency and EARFCN

The carrier frequency in the uplink and downlink is designated by the E-UTRA Absolute Radio Frequency Channel Number (EARFCN) in the range 0 - 65535. The relation between EARFCN and the carrier frequency in MHz for the downlink is given by the following equation, where F_{DL_low} and $N_{Offs\text{-}DL}$ are given in table 5.1.2-1 and N_{DL} is the downlink EARFCN.

$$F_{DL} = F_{DL\_low} + 0.1(N_{DL} – N_{Offs\text{-}DL})$$

The relation between EARFCN and the carrier frequency in MHz for the uplink is given by the following equation where F_{UL_low} and $N_{Offs\text{-}UL}$ are given in table 5.1.2-1 and N_{UL} is the uplink EARFCN.

$$F_{UL} = F_{UL\_low} + 0.1(N_{UL} – N_{Offs\text{-}UL})$$

E-UARFCN can be defined as in Table 5.1.2-1, by reserving a part of the unused numbers that follow the band 40 allocation.

Table 10.2-1: EARFCN allocated for E-UTRA Band [31]

E-UTRA Operating Band	Downlink			Uplink		
	F_{DL_low} [MHz]	$N_{Offs\text{-}DL}$	Range of N_{DL}	F_{UL_low} [MHz]	$N_{Offs\text{-}UL}$	Range of N_{UL}
[31]	462.5	[9870]	[9870 – 9919]	452.5	[27760]	[27760 – 27809]

11 Required changes to E-UTRA and MSR specifications

The required changes to the 3GPP specifications for the new band are summarised in a Table 11-1.

Table 11-1: Overview of 3GPP specifications with required changes

3GPP specification	Clause in TR 30.007 where the required changes are given	Clause in the present document identifying additional changes
TS 36.101	8.2.1.1	
TS 36.104	8.2.1.2	
TS 36.113	8.2.1.4	
TS 36.124	8.2.1.5	
TS 36.133	8.2.1.6	
TS 36.141	8.2.1.7	
TS 36.307	8.2.1.9	
TS 37.104	8.2.3.1	
TS 37.113	8.2.2.2	
TS 37.141	8.2.2.3	

Annex A (Informative): Analysis on BS Coexistence

A.1 Analysis on BS Coexistence with TV system

The lower edge of UHF-TV band is 2MHz above the DL band and 12 MHz above the UL band. According to current Brazilian channel allocation planning from ANATEL, Class C (ERP 1.6 kW) for analog stations and Class A (ERP 8 kW) for digital stations are considered as example scenarios in the blocking analysis.

A.1.1 ATV Transmitter → LTE BS Receiver (Blocking)

The blocking analysis for Class C ATV transmitter to LTE450 BS is shown in table A.1-1. Class C ATV transmit power (EIRP) is about 62+2.15 = 64.15 dBm/6MHz = 63.4 dBm/5MHz. The blocking requirement for LTE is -54 dBm for 1 dB desense. Due to UHF-TV band is above the LTE450 down link band, normally the rejection to DL band for RX filter is about 90 dB. Then the required antenna to antenna coupling loss between LTE BS and ATV station is about 33.15 dB, which can be easily achieved.

Table A.1-1: Interference analysis for Class C ATV to LTE450 BS

Item description	Unit	Value	Comment
Class C ATV transmit power (ERP)	kW	1.6	
Class C ATV transmit power (EIRP)	dBm/5MHz	63.4	
LTE receiver blocking requirement（6dB desense）	dBm/5MHz	-43	
LTE receiver blocking requirement（1dB desense）	dBm/5MHz	-54	
LTE BS antenna and feeder gain	dBi	12	It is a experience value referring to commercial CDMA450 antenna
Reduction in effective antenna gain	dB	-6	TS 25.942
Attenuation of duplexer	dB	90	
Required antenna to antenna coupling loss	dB	33.4	

A.1.2 DTV Transmitter → LTE BS Receiver (Blocking)

The blocking analysis for DTV transmitter to LTE450 BS is shown in table A.1-2. Class A DTV station transmit power (EIRP) is about 79+2.15 = 81.15 dBm/6MHz = 80.4 dBm/5MHz. The blocking requirement for LTE is -54 dBm for 1 dB desense. Due to UHF-TV band is above the LTE450 down link band, normally the rejection to DL band for RX filter is about 90 dB. Then the required antenna to antenna coupling loss between LTE BS and DTV transmitter is about 50.4 dB, which can be achieved in real deployment.

Table A.1-2: Interference analysis for DTV power to LTE450 BS

Item description	Unit	Value	Comment
DTV station transmit power (ERP)	kW	80	
DTV station transmit power (EIRP)	dBm/5MHz	80.4	
LTE receiver blocking requirement（6dB desense）	dBm/5MHz	-43	
LTE receiver blocking requirement（1dB desense）	dBm/5MHz	-54	
LTE BS antenna and feeder gain	dBi	12	It is a experience value referring to commercial CDMA450 antenna
Reduction in effective antenna gain	dB	-6	TS 25.942
Attenuation of duplexer	dB	90	
Required antenna to antenna coupling loss	dB	50.4	

A.1.3 LTE BS OOBE → DTV Receiver

The interference analysis for LTE450 BS OOBE to DTV receiver is shown in Table A.1-3. The allowed interference level in TV receiver is -77-18=-95 dBm/6MHz when analog TV transmitter is the interference source and -77-24=-101 dBm/6MHz when DTV transmitter is the interference source. Using -101 dBm/6MHz as the allowed interference level, the required antenna to antenna coupling loss between LTE BS and DTV receiver is 115 dB. The distance separation estimation for LTE BS interference to DTV receiver is shown in Table A.1-4. Recommendation ITU-R P.1546 was used to estimate the distance separation. It can be found that with 20 dB attenuation from the filter placed in the BS, the distance separation between LTE BS and DTV receivers can be less than 1 km.

Table A.1-3: Interference analysis for LTE450 BS OOBE to TV/DTV receiver

Item description	Unit	Value	Comment
TV minimum receiver level	dBm/6MHz	-77	ABNT-NBR-15604
Protection ratio for DTV	dB	24	ABNT-NBR-15604
Allowed interference level in DTV receiver	dBm/6MHz	-101	
LTE450 BS maximum transmitted power	dBm	43	
LTE450 BS ACLR	dBc	45	
BS unwanted emission in 470~476 MHz	dBm/6MHz	-1	
TV/DTV receiver antenna and feeder gain	dBi	9	APT-AWG-REP-24
LTE BS antenna and feeder gain	dBi	12	It is a experience value referring to commercial CDMA450 antenna
Reduction in effective antenna gain	dB	-6 dB	TS 25.942
Required antenna to antenna coupling loss	dB	115	

Table A.1-4: The distance separation estimation for LTE BS interference to DTV receiver

LTE 450 with filters	Distance separation
Distance at 0 dB (km)	3.9
Distance at 10 dB (km)	2
Distance at 20 dB (km)	< 1 km

A possible duplexer simulation can be found in Clause 7.2. It can be found that this duplexer can provide larger than 30 dB rejection at 470 MHz. In this case the emission interference from LTE BS to TV/DTV receiver will not be a problem.

Annex B: Change history

Change history							
Date	**TSG #**	**TSG Doc.**	**CR**	**Rev**	**Subject/Comment**	**Old**	**New**
2012-10	R4#64bis	R4-125149			Report skeleton		0.0.1
2012-11	R4#65	R4-126385			Agreed Text Proposal in RAN4 #64bis: R4-125149, "TR skeleton for LTE 450", Huawei, HiSilicon R4-125153, "Band specific issues for LTE 450", Huawei, HiSilicon R4-125744, "Regulations for 450 MHz band in Brazil", Qualcomm Incorporated	0.0.1	0.1.0
2013-01	R4#66	R4-130369			Agreed Text Proposal in RAN4 #65: R4-126927, "Additional regulatory requirements for 450 MHz in Brazil", CPqD, Qualcomm Incorporated	0.1.0	0.2.0
2013-04	R4#66bis	R4-131155			Agreed Text Proposal in RAN4 #66: R4-130915, "UE coexistence for LTE 450 band in Brazil", Qualcomm Incorporated R4-130916, "BS coexistence with TV system in UHF band", Huawei R4-130376, "BS coexistence with SARC", Huawei R4-130919, "BS coexistence with the limited services (SLMP, SLP, SLE)", Huawei R4-130920, "Discussion on BS implementation", Huawei R4-130370, "TP for LTE450 background", Huawei, HiSilicon	0.2.0	0.3.0
2013-05	R4#67	R4-132447			Agreed Text Proposal in RAN4 #66bis: R4-131818, "LTE 450 UE compatibility with UHF TV broadcast", Qualcomm Incorporated, Huawei, CPqD, Telecom Italia R4-131977, "TP for BS requirements", Huawei	0.3.0	0.4.0
2013-05	R4#67	R4-133087			Agreed Text Proposal in RAN4 #67: R4-133076, "TP on frequency band arrangement", Huawei, Qualcomm Incorporated, CPqD, Telecom Italia R4-133077, "CDMA sub-band A duplexer", Motorola Solutions R4-133078, "TP for LTE450 TR36.840", Motorola Solutions	0.4.0	0.5.0
2013-06	RAN#60	RP-130678			Presentation to RAN#60 for approval	0.5.0	1.0.0
2013-06	RAN#60	RP-130735			MCC requested clean-up	1.0.0	1.0.1