



Base Station (BS) Radio Transmission Minimum Requirements for LTE-U SDL

Presented at the LTE-U Forum workshop
on May 28, 2015 in San Diego, CA

Disclaimer and Copyright Notification

Disclaimer and Copyright Notification

Copyright © 2015 LTE-U Forum Companies: Alcatel-Lucent, Ericsson, LG Electronics, Qualcomm Technologies Inc., Samsung Electronics, Verizon. All rights reserved.

This document provides initial information related to Long Term Evolution (LTE) technology operation using unlicensed spectrum as a Supplemental Downlink to LTE technology operation using licensed spectrum. All information provided herein is subject to change without notice. The information provided herein was considered technically accurate by the LTE-U Forum Companies at the time the documents were initially published, but LTE-U Forum Companies disclaim and make no guaranty or warranty, express or implied, as to the accuracy or completeness of any information contained or referenced herein. LTE-U FORUM COMPANIES DISCLAIM ANY IMPLIED WARRANTY OF MERCHANTABILITY, NON-INFRINGEMENT, OR FITNESS FOR ANY PARTICULAR PURPOSE, AND ALL SUCH INFORMATION IS PROVIDED ON AN "AS-IS" BASIS. Other than as explicitly provided below, LTE-U Forum is not providing any licenses under any intellectual property of any kind owned by any person (whether an LTE-U Forum Company or otherwise) that may be necessary to access or utilize any of the information contained herein, including but not limited to any source materials referenced herein, and any patents required to implement or develop any technology described herein. It shall be the responsibility of the developer to obtain any such licenses, if necessary.

LTE-U Forum disclaims liability for any damages or losses of any nature whatsoever whether direct, indirect, special or consequential resulting from the use of or reliance on any information contained or referenced herein.

Permission is given to reproduce this document in its entirety solely for the review, analysis, and implementation of LTE-U. Use of this document for any other reason without the permission of LTE-U Forum Companies is explicitly prohibited.

LTE-U SDL Band Combinations

- 5GHz SDL aggregated with licensed FDD was defined for
 - U-NII-1: Band number 252 for U-NII-1 spectrum (5150-5250 MHz)
 - U-NII-3: Band number 255 for U-NII-3 spectrum (5725-5850 MHz)

Table 4.3-1: LTE-U SDL CA scenarios *

#	Band Combination	Licensed Band	Unlicensed Band	BW (MHz)	CA configuration
1	B13+B252+B252	B13	U-NII-1	10+20+20	inter-band + unlicensed intra-band contiguous DL CA w/o UL CA
	B13+B255+B255	B13	U-NII-3	10+20+20	
2	B13+B252	B13	U-NII-1	10+20	inter-band DL CA without UL CA
	B13+B255	B13	U-NII-3	10+20	
3	B2+B252+B252	B2	U-NII-1	[5,10,15,20]+20+20	inter-band + unlicensed intra-band contiguous DL CA w/o UL CA
	B2+B255+B255	B2	U-NII-3	[5,10,15,20]+20+20	
4	B2+B252	B2	U-NII-1	[5,10,15,20]+20	inter-band DL CA without UL CA
	B2+B255	B2	U-NII-3	[5,10,15,20]+20	
5	B4+B252+B252	B4	U-NII-1	[5, 10, 15, 20] +20+20	inter-band + unlicensed intra-band contiguous DL CA w/o UL CA
	B4+B255+B255	B4	U-NII-3	[5, 10, 15, 20] +20+20	
6	B4+B252	B4	U-NII-1	[5, 10, 15, 20] +20	inter-band DL CA without UL CA
	B4+B255	B4	U-NII-3	[5, 10, 15, 20] +20	

* From LTE-U Forum Technical Report v1.0

BS radio transmission requirements for LTE-U SDL

➤ BS radio transmission minimum performance requirements based on **3GPP TS 36.104** covers transmitter characteristics

- Output power
- Adjacent Channel Leakage power Ratio (ACLR)
- Operating band unwanted emissions
- Spurious emissions
- Co-location

BS Rated Output Power for LTE-U

Table 6.2.2-3: Regional requirements for Band 252 and Band 255 for rated output power declared by the manufacturer*.

Channel bandwidth BW_{Channel} [MHz]	1.4	3	5	10	15	20
Maximum output power [W]	N/A	N/A	N/A	N/A	N/A	1 ^{1, 2}

NOTE 1: Maximum conducted output power limit is defined for a single transmitting antenna with a gain equal to or less than 6dBi. If the antenna gain is greater than 6 dBi, the maximum conducted output power limit shall be reduced by the amount in dB that antenna gain exceeds 6 dBi. If multiple antennas are used for transmission, the maximum conducted power limit shall be reduced by the amount equal to $10 \cdot \log$ (the number of transmitting antennas).

NOTE 2: Regional regulatory requirements may further limit the maximum transmit power and antenna radiation characteristics, such as those defined in FCC Subpart E that limit EIRP versus elevation angle for an outdoor Band 252 BS.

*From LTE-U Forum modifications to 3GPP TS36.104

BS Regional Maximum Power Spectral Density for LTE-U

Table 6.2.2-4 Regional maximum power spectral density requirements*

E-UTRA Operating Band	Power Spectral Density	Note
252	17 dBm/MHz	1
255	30 dBm/500kHz	1
NOTE 1: Requirements are sourced from FCC CFR47 Part 15.407(a).		

*From LTE-U Forum modifications to 3GPP TS36.104

BS Adjacent Channel Leakage Ratio for LTE-U

**Table 6.6.2.1-1b: Medium Range and Local Area BS
ACLR in band 252 and band 255***

Channel bandwidth of E-UTRA lowest (highest) carrier transmitted BW_{Channel} [MHz]	BS adjacent channel centre frequency offset below the lowest or above the highest carrier centre frequency transmitted	Assumed adjacent channel carrier (informative)	Filter on the adjacent channel frequency and corresponding filter bandwidth	ACLR limit
20	BW_{Channel}	E-UTRA of same BW	Square (BW_{Config})	30 dB
	$2 \times BW_{\text{Channel}}$	E-UTRA of same BW	Square (BW_{Config})	30 dB
NOTE 1: BW_{Channel} and BW_{Config} are the channel bandwidth and transmission bandwidth configuration of the E-UTRA lowest (highest) carrier transmitted on the assigned channel frequency.				

*From LTE-U Forum modifications to 3GPP TS36.104



BS Operating Band Unwanted Emissions for LTE-U

Table 6.6.3.2A-4: Local Area BS operating band unwanted emission limits for 20 MHz channel bandwidth when operating in Bands 252 and 255*

Frequency offset of measurement filter -3dB point, Δf	Frequency offset of measurement filter centre frequency, f_{offset}	Minimum requirement (Note 1, 2)) (dBm)	Measurement bandwidth (Note 5)
$0 \text{ MHz} \leq \Delta f < 1 \text{ MHz}$	$0.05 \text{ MHz} \leq f_{offset} < 1.05 \text{ MHz}$	$P \text{ (dBm)} - 32.6\text{dB}$ $-10 \left(\frac{f_{offset}}{\text{MHz}} - 0.05 \right) \text{ dB}$	100 kHz
$1 \text{ MHz} \leq \Delta f < \min(10 \text{ MHz}, \Delta f_{max})$	$1.05 \text{ MHz} \leq f_{offset} < \min(10.05 \text{ MHz}, f_{offset_{max}})$	$P \text{ (dBm)} - 42.6\text{dB}$ $-\frac{8}{9} \left(\frac{f_{offset}}{\text{MHz}} - 1.05 \right) \text{ dB}$	100 kHz
$10 \text{ MHz} \leq \Delta f < \min(20 \text{ MHz}, \Delta f_{max})$	$10.05 \text{ MHz} \leq f_{offset} < \min(20.05 \text{ MHz}, f_{offset_{max}})$	$P \text{ (dBm)} - 50.6\text{dB}$ $-\frac{12}{10} \left(\frac{f_{offset}}{\text{MHz}} - 10.05 \right) \text{ dB}$	100kHz
$20 \text{ MHz} \leq \Delta f \leq \Delta f_{max}$	$20.05 \text{ MHz} \leq f_{offset} < f_{offset_{max}}$	$P \text{ (dBm)} - 62.6\text{dB}$	100 kHz
<p>NOTE 1: For a BS supporting non-contiguous spectrum operation within any operating band the minimum requirement within sub-block gaps is calculated as a cumulative sum of contributions from adjacent sub blocks on each side of the sub block gap. Exception is $\Delta f \geq 10\text{MHz}$ from both adjacent sub blocks on each side of the sub-block gap, where the minimum requirement within sub-block gaps shall be -37dBm/100kHz.</p> <p>NOTE 2: For BS supporting multi-band operation with inter RF bandwidth gap < 20MHz the minimum requirement within the inter RF bandwidth gaps is calculated as a cumulative sum of contributions from adjacent sub-blocks on each side of the inter RF bandwidth gap.</p>			

P (dBm) is the maximum output power at the antenna connector for the 20 MHz channel.

*From LTE-U Forum modifications to 3GPP TS36.104

BS Operating Band Unwanted Emissions for LTE-U

Table 6.6.3.2A-5: Local Area BS operating band unwanted emission limits for 20+20 MHz channel bandwidth when operating in Bands 252 and 255*

Frequency offset of measurement filter -3dB point, Δf	Frequency offset of measurement filter centre frequency, f_{offset}	Minimum requirement (Note 1, 2)) (dBm)	Measurement bandwidth (Note 5)
$0 \text{ MHz} \leq \Delta f < 1 \text{ MHz}$	$0.05 \text{ MHz} \leq f_{\text{offset}} < 1.05 \text{ MHz}$	$P(\text{dBm}) - 32.6\text{dB}$ $-10 \left(\frac{f_{\text{offset}}}{\text{MHz}} - 0.05 \right) \text{dB}$	100 kHz
$1 \text{ MHz} \leq \Delta f < \min(20 \text{ MHz}, \Delta f_{\text{max}})$	$1.05 \text{ MHz} \leq f_{\text{offset}} < \min(20.05 \text{ MHz}, \bar{f}_{\text{offset}_{\text{max}}})$	$P(\text{dBm}) - 42.6\text{dB}$ $-\frac{8}{19} \left(\frac{f_{\text{offset}}}{\text{MHz}} - 1.05 \right) \text{dB}$	100 kHz
$20 \text{ MHz} \leq \Delta f < \min(40 \text{ MHz}, \Delta f_{\text{max}})$	$20.05 \text{ MHz} \leq f_{\text{offset}} < \min(40.05 \text{ MHz}, \bar{f}_{\text{offset}_{\text{max}}})$	$P(\text{dBm}) - 50.6\text{dB}$ $-\frac{12}{20} \left(\frac{f_{\text{offset}}}{\text{MHz}} - 20.05 \right) \text{dB}$	100kHz
$40 \text{ MHz} \leq \Delta f \leq \Delta f_{\text{max}}$	$40.05 \text{ MHz} \leq f_{\text{offset}} < \bar{f}_{\text{offset}_{\text{max}}}$	$P(\text{dBm}) - 62.6\text{dB}$	100 kHz
<p>NOTE 1: For a BS supporting non-contiguous spectrum operation within any operating band the minimum requirement within sub-block gaps is calculated as a cumulative sum of contributions from adjacent sub blocks on each side of the sub block gap. Exception is $\Delta f \geq 10\text{MHz}$ from both adjacent sub blocks on each side of the sub-block gap, where the minimum requirement within sub-block gaps shall be -37dBm/100kHz.</p> <p>NOTE 2: For BS supporting multi-band operation with inter RF bandwidth gap < 20MHz the minimum requirement within the inter RF bandwidth gaps is calculated as a cumulative sum of contributions from adjacent sub-blocks on each side of the inter RF bandwidth gap.</p>			

$P(\text{dBm})$ is the maximum output power (per carrier) at the antenna connector for the 20+20 MHz channels.

*From LTE-U Forum modifications to 3GPP TS36.104

BS Additional Emissions Requirements for Band 252

Table 6.6.3.3-10: Declared emissions levels for E-UTRA Band 252*

Operating Band	Measurement Filter centre frequency, F_{filter}	Measurement bandwidth	Declared emission level [dBm]
252	$F_{\text{filter}} \leq 5149.5\text{MHz}$ and $\geq 5350.5\text{MHz}$	1 MHz	P_{E_B252}

$P_{\text{EIRP}} = P_E + G_{\text{ant}} + 10 \cdot \log(N_{\text{ant}})$ where where P_E denotes the BS unwanted emission level at the antenna connector, G_{ant} equals the BS antenna gain minus feeder loss, and N_{ant} denotes the number of transmitting antennas.

Table H.2-1: EIRP limits for E-UTRA Bands 252 and 255*

Operating Band	Measurement Filter centre frequency, F_{filter}	Measurement bandwidth	Maximum emission level P_{EIRP} [dBm]
252	$F_{\text{filter}} \leq 5149.5\text{MHz}$ and $\geq 5350.5\text{MHz}$	1 MHz	-27
255	$5715.5\text{MHz} \leq F_{\text{filter}} \leq 5724.5\text{MHz}$ and $5850.5\text{MHz} \leq F_{\text{filter}} \leq 5859.5\text{MHz}$	1 MHz	-17
255	$F_{\text{filter}} \leq 5714.5\text{MHz}$ and $\geq 5860.5\text{MHz}$	1 MHz	-27

*From LTE-U Forum modifications to 3GPP TS36.104

BS Additional Emissions Requirements for Band 255

Table 6.6.3.3-11: Declared emissions levels for E-UTRA Band 255*

Operating Band	Measurement Filter centre frequency, F_{filter}	Measurement bandwidth	Declared emission level [dBm]
255	$5715.5\text{MHz} \leq F_{\text{filter}} \leq 5724.5\text{MHz}$ and $5850.5\text{MHz} \leq F_{\text{filter}} \leq 5859.5\text{MHz}$	1 MHz	$P_{E_B255, a}$
255	$F_{\text{filter}} \leq 5714.5\text{MHz}$ and $\geq 5860.5\text{MHz}$	1 MHz	$P_{E_B255, b}$

$P_{\text{EIRP}} = P_E + G_{\text{ant}} + 10 \cdot \log(N_{\text{ant}})$ where where P_E denotes the BS unwanted emission level at the antenna connector, G_{ant} equals the BS antenna gain minus feeder loss, and N_{ant} denotes the number of transmitting antennas.

Table H.2-1: EIRP limits for E-UTRA Bands 252 and 255*

Operating Band	Measurement Filter centre frequency, F_{filter}	Measurement bandwidth	Maximum emission level P_{EIRP} [dBm]
252	$F_{\text{filter}} \leq 5149.5\text{MHz}$ and $\geq 5350.5\text{MHz}$	1 MHz	-27
255	$5715.5\text{MHz} \leq F_{\text{filter}} \leq 5724.5\text{MHz}$ and $5850.5\text{MHz} \leq F_{\text{filter}} \leq 5859.5\text{MHz}$	1 MHz	-17
255	$F_{\text{filter}} \leq 5714.5\text{MHz}$ and $\geq 5860.5\text{MHz}$	1 MHz	-27

*From LTE-U Forum modifications to 3GPP TS36.104

BS Spurious Emission Limits for LTE-U

Table 6.6.4.1.3.1-1: BS Spurious emissions limits, LTE-U*

Frequency range	Maximum Level	Measurement Bandwidth	Note
9 kHz ↔ 150 kHz	-46 dBm	0.2kHz	Note 1, 2, 5
150 kHz ↔ 30 MHz	-46 dBm	9 kHz	Note 1, 2, 5
30 MHz ↔ 88 MHz	-55 dBm	120 kHz	Note 1, 2, 5
88 MHz ↔ 216 MHz	-52 dBm	120 kHz	Note 1, 2, 5
216 MHz ↔ 960 MHz	-49 dBm	120 kHz	Note 1, 2, 5
960 MHz ↔ 1000 MHz	-41 dBm	120 kHz	Note 1, 2, 5
1 GHz ↔ 12.75 GHz	NOTE 3	1 MHz	Note 1, 2, 5
12.75 GHz ↔ 40 GHz	NOTE 3	1 MHz	Note 1, 2, 5
FCC 15.205 Restricted Bands above 1000 MHz	-41 dBm	1 MHz	Note 1, 2, 3, 4, 5, 6

NOTE 1: Limits are sourced from US FCC CFR 47 Part 15.209

NOTE 2 Applicable regional regulatory requirements, such as FCC CFR 47 Subpart E, define radiated emissions from the BS in terms of field strength with units of microvolts/meter using a CISPR 16 quasi-peak detector function on frequencies <1000MHz and an average detector for frequencies >1000 MHz. The field strength limits may be converted to isotropic radiated power (EIRP) and then conducted emissions limits based on an assumed antenna gain. The limits have been converted from FCC Part 15.209 electric field strength limits to conducted RF emissions limits assuming an antenna gain of 0 dBi.

NOTE 3: See section 6.6.3.3 for emissions limits > 1GHz

NOTE 4: Restricted bands are defined in US FCC CFR 47 Part 15.205

NOTE 5: If multiple antennas are used for transmission, the maximum conducted spurious emissions limit shall be reduced by the amount equal to $10 \cdot \log(\text{the number of transmitting antennas})$.

NOTE 6: FCC CFR 47 Part 15.209 restricted band emissions limits < 1000 MHz are addressed in this table by the limits in the range of 9 kHz to 1000 MHz

*From LTE-U Forum modifications to 3GPP TS36.104

FCC CFR 47 Part 15.205 Restricted Bands

Table H.3-1: FCC Part 15.205 Restricted Bands*

Frequency Range	Frequency Range	Frequency Range	Frequency Range
0.090-0.110 MHz	16.42-16.423 MHz	399.9-410 MHz	4.5-5.15 GHz
10.495-0.505 MHz	16.69475-16.69525 MHz	608-614 MHz	5.35-5.46 GHz
2.1735-2.1905 MHz	16.80425-16.80475 MHz	960-1240 MHz	7.25-7.75 GHz
4.125-4.128 MHz	25.5-25.67 MHz	1300-1427 MHz	8.025-8.5 GHz
4.17725-4.17775 MHz	37.5-38.25 MHz	1435-1626.5 MHz	9.0-9.2 GHz
4.20725-4.20775 MHz	73-74.6 MHz	1645.5-1646.5 MHz	9.3-9.5 GHz
6.215-6.218 MHz	74.8-75.2 MHz	1660-1710 MHz	10.6-12.7 GHz
6.26775-6.26825 MHz	108-121.94 MHz	1718.8-1722.2 MHz	13.25-13.4 GHz
6.31175-6.31225 MHz	123-138 MHz	2200-2300 MHz	14.47-14.5 GHz
8.291-8.294 MHz	149.9-150.05 MHz	2310-2390 MHz	15.35-16.2 GHz
8.362-8.366 MHz	156.52475-156.52525 MHz	2483.5-2500 MHz	17.7-21.4 GHz
8.37625-8.38675 MHz	156.7-156.9 MHz	2690-2900 MHz	22.01-23.12 GHz
8.41425-8.41475 MHz	162.0125-167.17 MHz	3260-3267 MHz	23.6-24.0 GHz
12.29-12.293 MHz	167.72-173.2 MHz	3332-3339 MHz	31.2-31.8 GHz
12.51975-12.52025 MHz	240-285 MHz	3345.8-3358 MHz	36.43-36.5 GHz
12.57675-12.57725 MHz	322-335.4 MHz	3600-4400 MHz	
13.36-13.41 MHz			

*From LTE-U Forum modifications to 3GPP TS36.104

BS radio transmission minimum requirements (1 of 3)

Section	Requirement	Description of changes in TS 36.104*
4.3	Regional requirements	Added reference to the regional requirements applicable to base stations operating in LTE-U band in Table 4.3-1.
5.5	Operating bands	Added LTE-U operating band to Table 5.5-1. Added the carrier aggregation combination of licensed operating band plus LTE-U operating band in table 5.5-3.
5.7.3	Carrier frequency and EARFCN	Added LTE-U operating band entry and associated EARFCN set to Table 5.7.3-1.
6.2.2	Additional base station output power requirement (regional)	Added the additional regional requirements in Tables 6.2.2-3 and 6.2.2-4 applicable to LTE-U operating band base station.
6.6.2.1	Minimum ACLR requirement	Added Tables 6.6.2.1-1b for Medium Range and Local area BS ACLR limits applicable to LTE-U operating band base station..

*From LTE-U Forum modifications to 3GPP TS36.104

BS radio transmission minimum requirements (2 of 3)

Section	Requirement	Description of changes in TS 36.104*
6.6.3.1	Operating band unwanted emission	Added LTE-U operating band in Clause 6.6.3.1.
6.6.3.2A	Minimum requirements for Local Area BS (Category A and B)	Added Tables 6.6.3.2A-4 and 6.6.3.2A-5 for Local Area BS unwanted emissions limit applicable to LTE-U operating band base station.
6.6.3.2C	Minimum requirements for Medium Range BS (Category A and B)	Added Tables 6.6.3.2C-7 and 6.6.3.2C-8 for Medium Range BS unwanted emissions limit applicable to LTE-U operating band base station.
6.6.3.3	Additional (operating band unwanted emissions) requirements	Added Tables 6.6.3.3-10 and 6.6.3.3-11 to define the additional regional requirements applicable to LTE-U operating band base station with EIRP and emission limits defined in Annex H2.

*From LTE-U Forum modifications to 3GPP TS36.104

BS radio transmission minimum requirements (3 of 3)

Section	Requirement	Description of changes in TS 36.104*
6.6.4.1.3	Spurious emissions (LTE-U)	Added Table 6.6.4.1.3.1-1 for LTE-U operating band BS spurious emission limits.
6.6.4.3	Additional spurious emissions requirements	Added LTE-U operating band to Tables 6.6.4.3.1-1 with standard DL requirements.
6.6.4.4	Co-location spurious emissions requirements	Added LTE-U operating band to Tables 6.6.4.4.1-2 and 6.6.4.4.1-3 with standard DL requirements.
7.6.2	Co-location with other base stations	Added LTE-U operating band to Tables 7.6.2.1-2 and 7.6.2.1-3 with standard E-UTRA requirements.
Annex H2	(Informative): Regional emission requirement for LTE-U operating bands	Specified a conversion equation (from emission EIRP limits to emission limits at the antenna connector) and the values of regional emission EIRP limits.
Annex H3	(Informative): FCC CFR 47 Part 15.205 Restricted Bands	Added Table H-3.1 to provide the restricted bands.

*From LTE-U Forum modifications to 3GPP TS36.104

Next Steps

- LTE-U Forum members encourage industry to review the published Spec Release 1.0
- LTE-U Forum is open to feedbacks and comments, with member-agreed CRs to enhance future releases for bug fixes
- Associated LTE-U BS conformance testing requirements to come soon
- LTE-U Forum documents are available at:
 - <http://www.lteuforum.org/>