Radio Performance of 4G-LTE Terminal

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Course Objectives:

Throughout the course the trainee should be able to:

1. get a clear overview of the system architecture of LTE;
2. have a logical understanding of LTE Radio frequency;
3. figure out the scope and method of LTE terminal RF Conformance.

Agenda

1. LTE Introduction
2. LTE Physical Layer
3. LTE Radio Frequency
4. LTE RF Conformance

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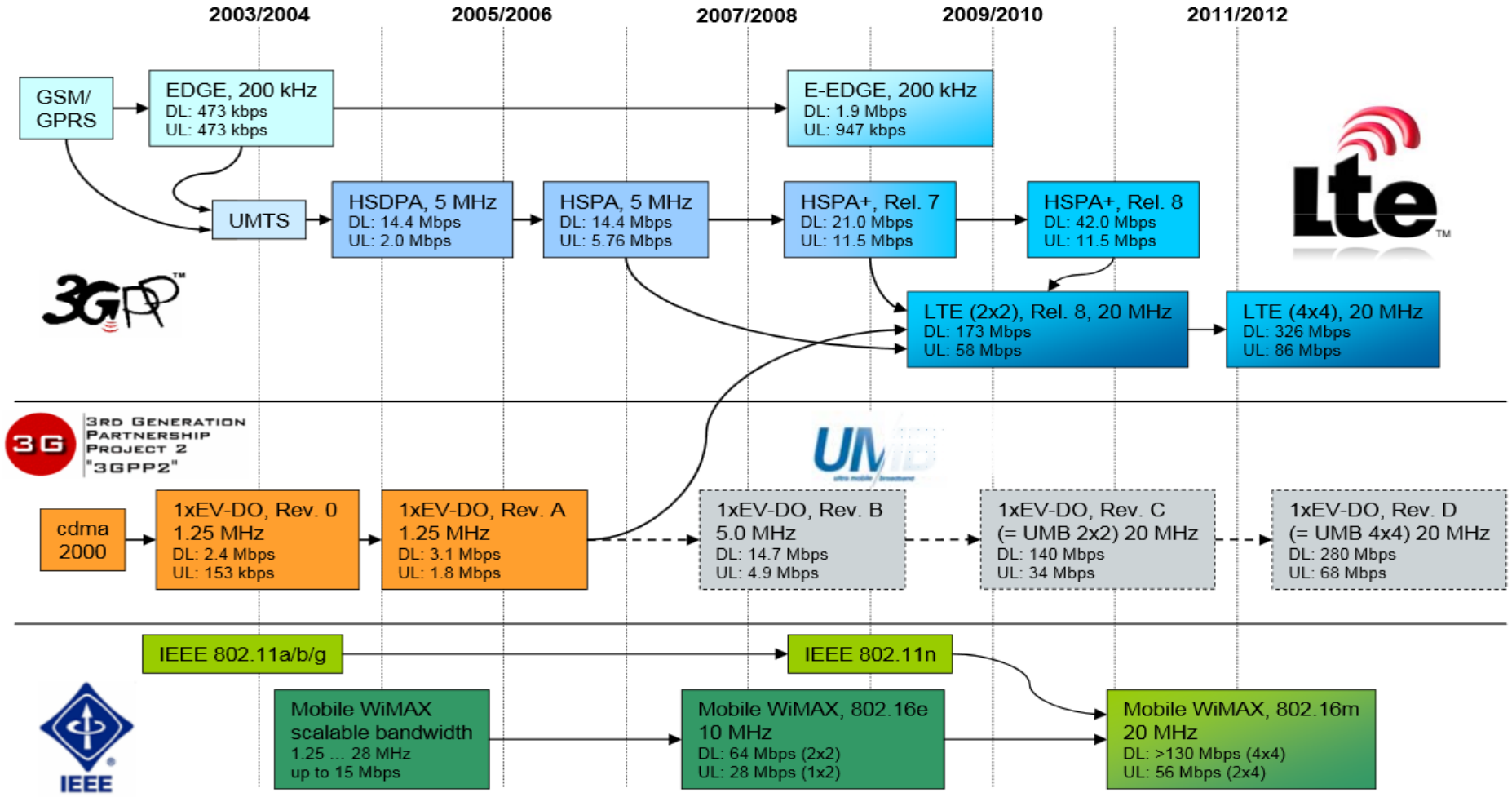
1. LTE Introduction
2. LTE Physical Layer
3. LTE Radio Frequency
4. LTE RF Conformance

1. LTE Introduction

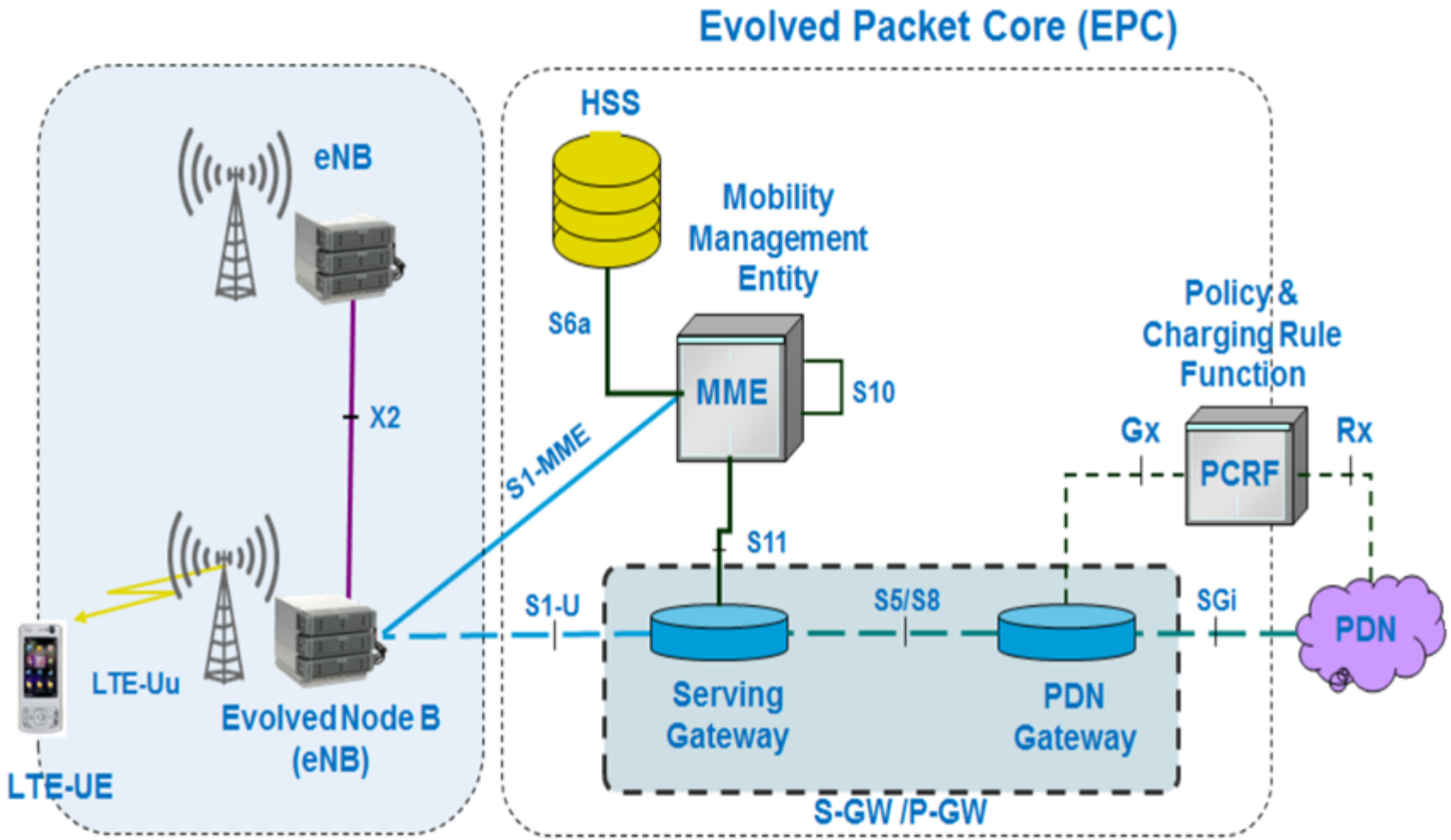


1. LTE Introduction

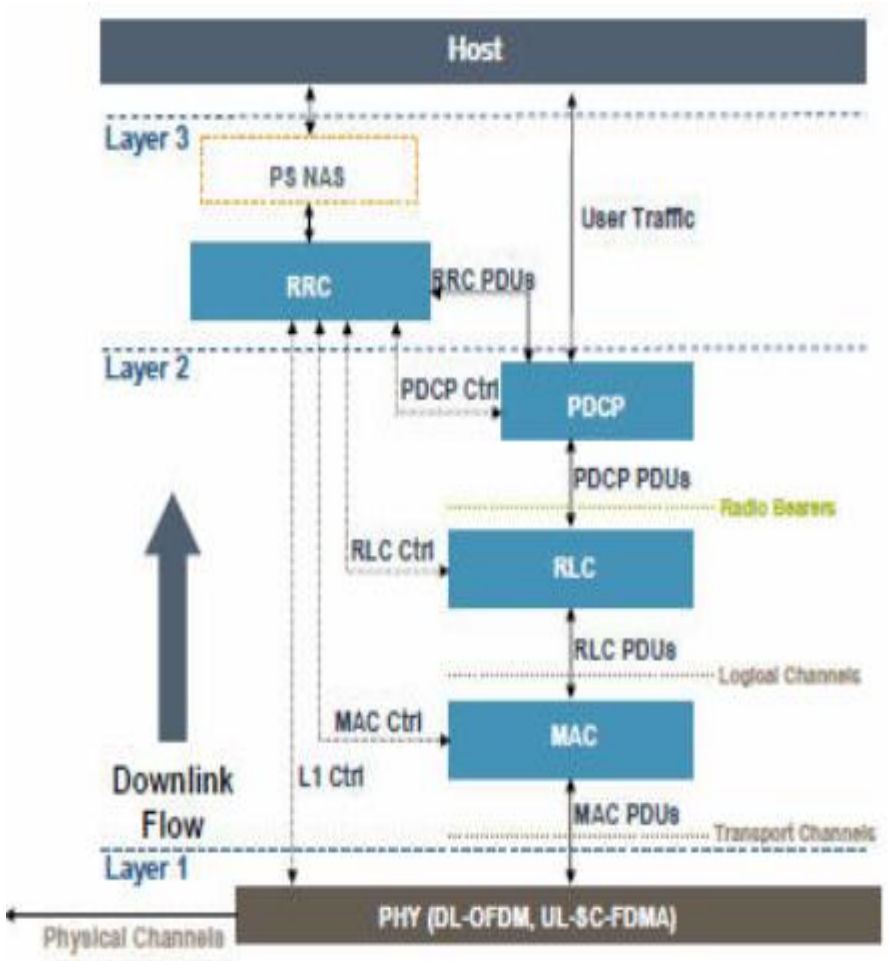
- "Operators can flexibly introduce LTE to match their existing network and spectrum, to meet business objectives for mobile broadband."
- LTE offers several important benefits for users and operators:

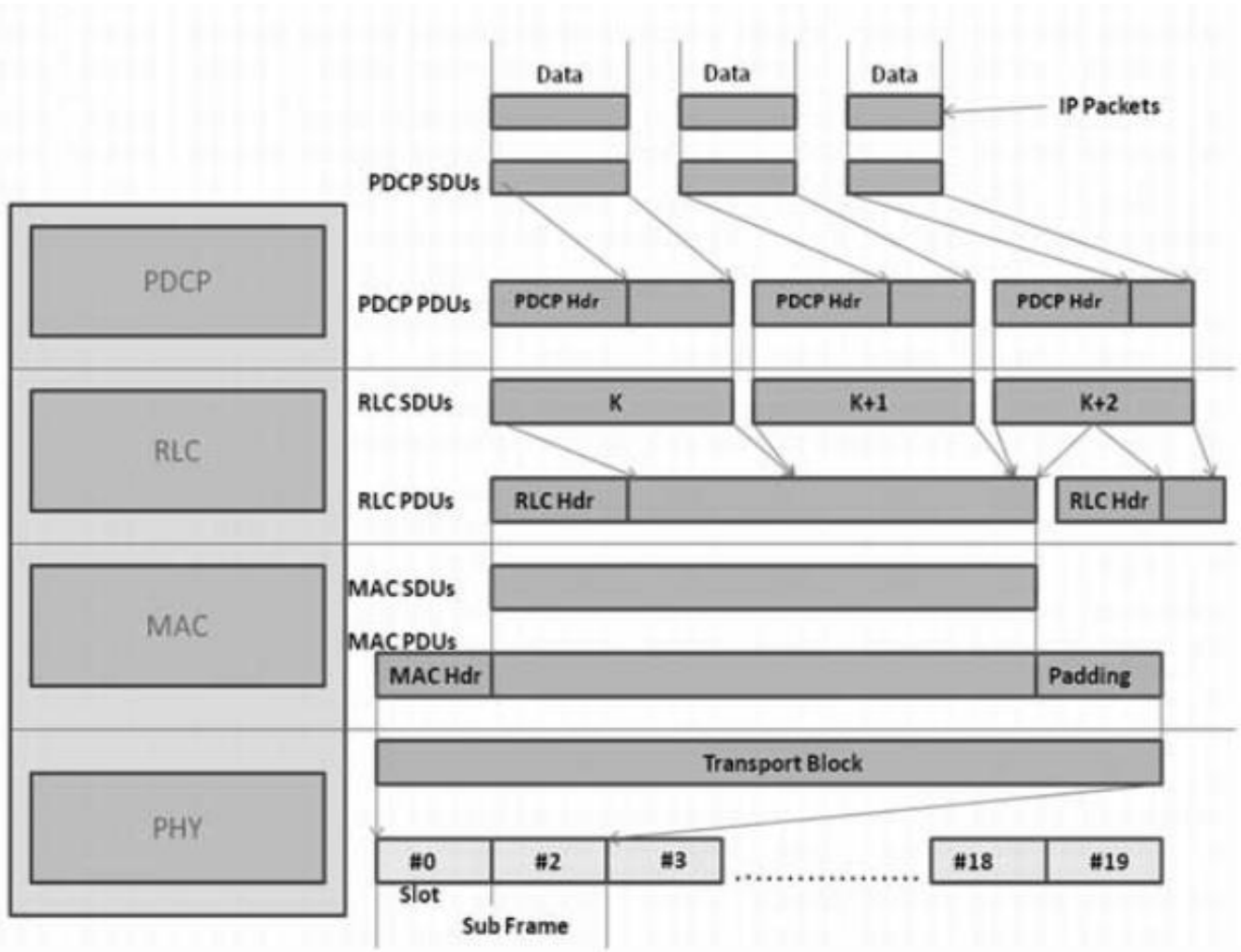
1. Performance and capacity – LTE should provide downlink peak rates of at least 100Mbps.
2. Simplicity – LTE supports flexible carrier bandwidths, from 1.4MHz up to 20MHz. LTE also supports both frequency division duplex (FDD) and time division duplex (TDD).
3. Wide range of terminals – in addition to mobile phones and MiFi`s, many consumer electronic or M2M devices incorporate LTE embedded modules.
4. Mobility and coverage - LTE supports handover and roaming to existing mobile networks.

1. LTE Introduction



1. LTE Introduction





1. LTE Introduction

Frequency Range	**UMTS FDD bands and UMTS TDD bands**					
Channel bandwidth 1 Resource Block (RB) =180 kHz	**1.4 MHz**	**3 MHz**	**5 MHz**	**10 MHz**	**15 MHz**	**20 MHz**
	6 RB	15 RB	25 RB	50 RB	75 RB	100 RB
Modulation Schemes	**Downlink**	QPSK, 16QAM, 64QAM				
	Uplink	QPSK, 16QAM, 64QAM (⇨ optional for handset)				
Multiple Access	**Downlink**	OFDMA (Orthogonal Frequency Division Multiple Access)				
	Uplink	SC-FDMA (Single Carrier Frequency Division Multiple Access)				
MIMO technology	**Downlink**	Wide choice of MIMO configuration options for transmit diversity, spatial multiplexing, and cyclic delay diversity (max. 4 antennas at base station and handset)				
	Uplink	Multi-user collaborative MIMO				
Peak Data Rate	**Downlink**	150 Mbps (UE category 4, 2x2 MIMO, 20 MHz) 300 Mbps (UE category 5, 4x4 MIMO, 20 MHz)				
	Uplink	75 Mbps (20 MHz)				

1. LTE Introduction

UE category		Max data rate in Mbps		Min. number of DL CCs	DL MIMO layer(s)	Highest Modulation Scheme	
		DL	UL			DL	UL
Rel8	1	~10	~5	1	1	64QAM	16QAM
	2	~50	~25		2		
	3	~100	~50				
	4	~150					
	5	~300	~75		4		64QAM
Rel10	6	~300	~50	1 or 2	2 or 4		16QAM
	7	~300	~100				
	8	~3000	~1500	5	8		64QAM
Rel11	9	~450	~50	2 or 3	2 or 4		16QAM
	10		~100				
	11	~600	~50	2, 3 or 4			
	12		~100				

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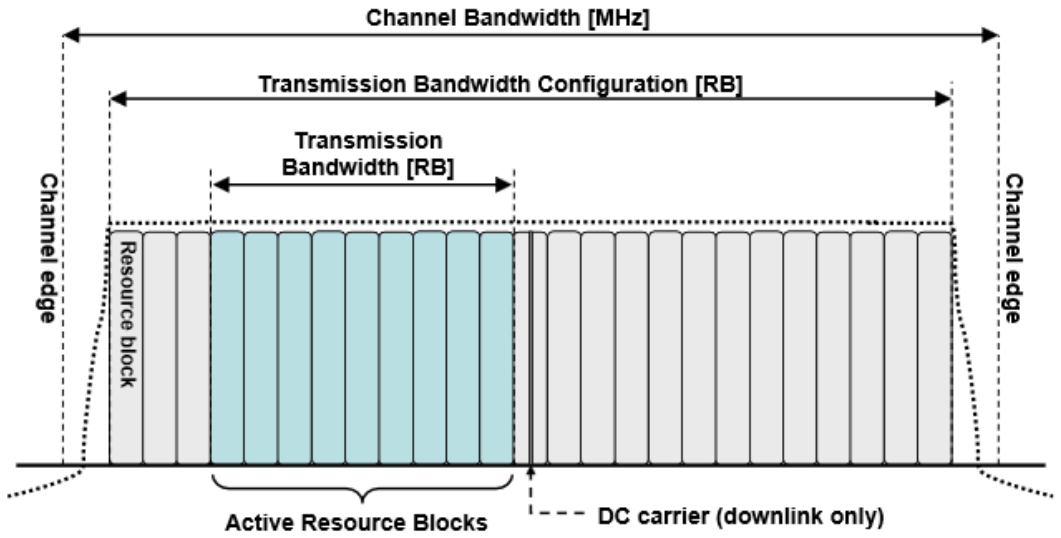
4. LTE RF Conformance

2. LTE Physical Layer

- LTE physical layer (FDD/TDD) supports bandwidth from 1.4 to 20 MHz.
- Current LTE supports a subset of 6 different system bandwidths.

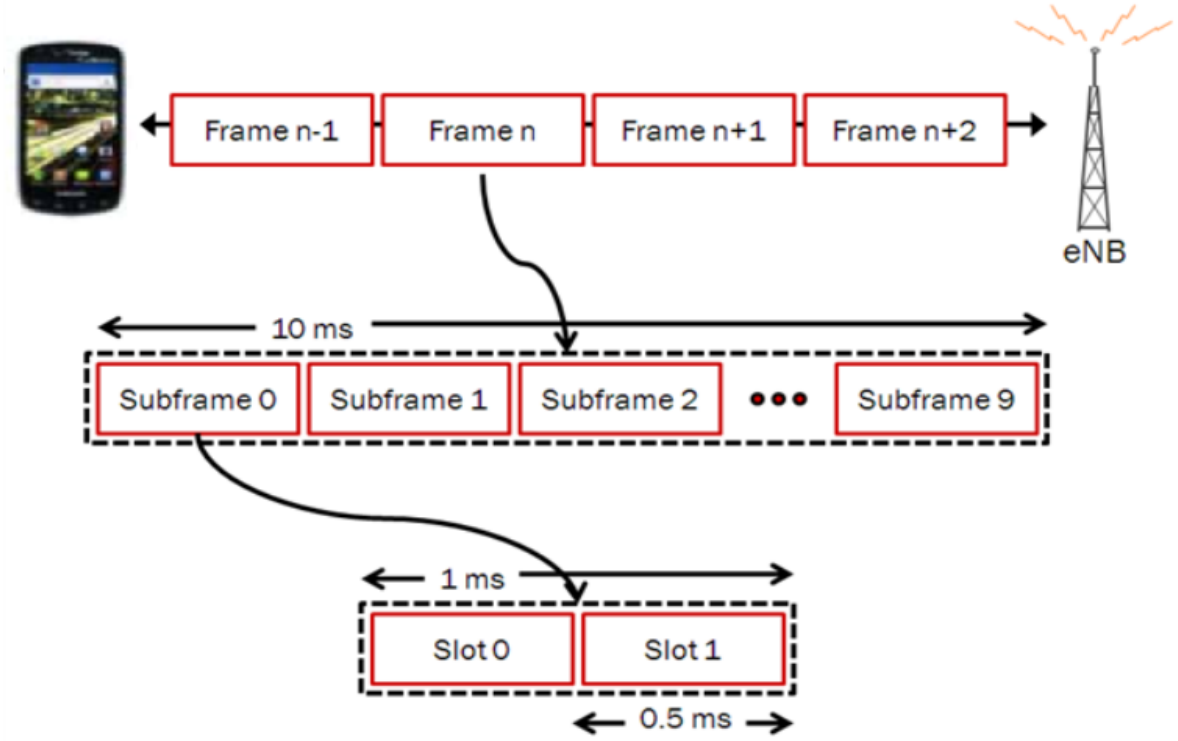
Channel bandwidth $BW_{Channel}$ [MHz]	1.4	3	5	10	15	20
Number of resource blocks	6	15	25	50	75	100



E-UTRA band / Channel bandwidth						
E-UTRA Band	1.4 MHz	3 MHz	5 MHz	10 MHz	15 MHz	20 MHz
1			Yes	Yes	Yes	Yes
2	Yes	Yes	Yes	Yes	Yes	Yes
3	Yes	Yes	Yes	Yes	Yes	Yes
4	Yes	Yes	Yes	Yes	Yes	Yes
5	Yes	Yes	Yes	Yes		
6			Yes	Yes		
7			Yes	Yes	Yes	Yes
8	Yes	Yes	Yes	Yes		
9			Yes	Yes	Yes	Yes
10			Yes	Yes	Yes	Yes
11			Yes	Yes		
12	Yes	Yes	Yes	Yes		
13			Yes	Yes		
14			Yes	Yes		
...						

2. LTE Physical Layer

- LTE FDD Frame Structure Type 1
  - 1 frame = 10 ms = 10 subframe
  - 1 subframe = 2 slot(0.5ms)
  - Subcarrier spacing = 15 kHz



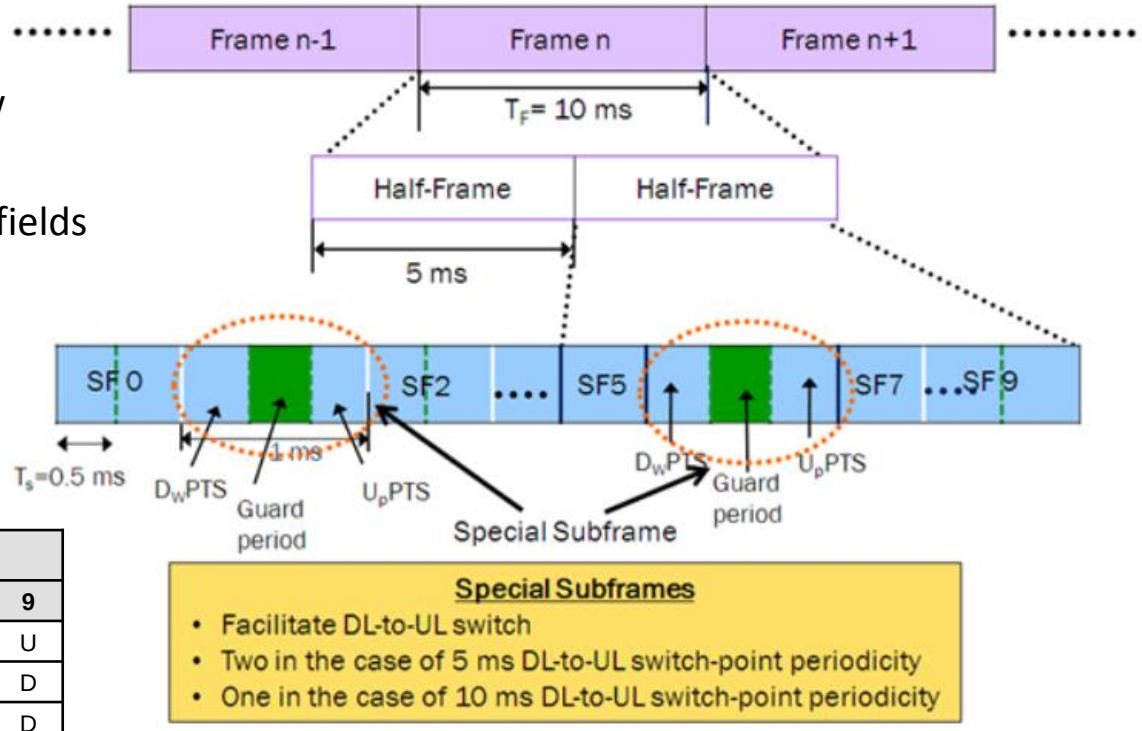
2. LTE Physical Layer

- ## LTE TDD Frame Structure Type 2
  - One radio frame = 10 ms = 2 half-frames = 10 subframw
  - Subframes 0 and 5 always for DL
  - Special subframe with various partitioning of following fields

    DwPTS – DL

    GP – Guard period

    UpPTS – UL, always followed by an UL subframe
  - Supports 7 different UL/DL configurations



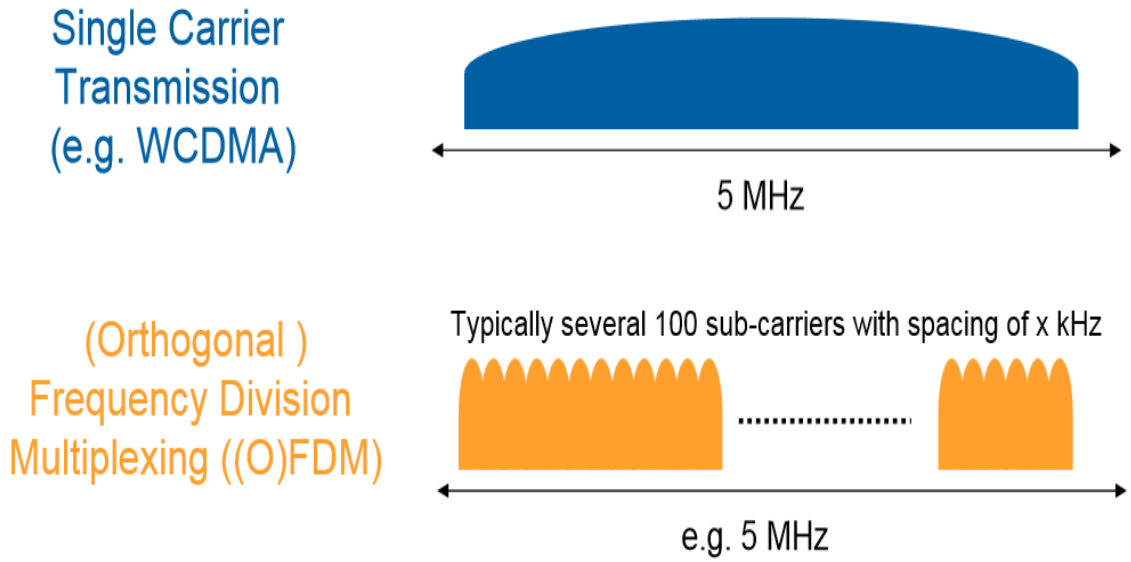
Uplink-downlink Configuration	Downlink-to-Uplink Switch-point periodicity	Subframe number									
		0	1	2	3	4	5	6	7	8	9
0	5 ms	D	S	U	U	U	D	S	U	U	U
1	5 ms	D	S	U	U	D	D	S	U	U	D
2	5 ms	D	S	U	D	D	D	S	U	D	D
3	10 ms	D	S	U	U	U	D	D	D	D	D
4	10 ms	D	S	U	U	D	D	D	D	D	D
5	10 ms	D	S	U	D	D	D	D	D	D	D
6	5 ms	D	S	U	U	U	D	S	U	U	D

2. LTE Physical Layer

- Orthogonal Frequency Division Multiplex (OFDM) is a multi-carrier transmission technique, which divides the available spectrum into many subcarriers, each one being modulated by a low data rate stream.

Advantages:

- High spectral efficiency.
- Robust against NB co-channel interference, fading.
- Can easily adapt to severe channel conditions.
- Low sensitivity to time sync. Errors.



Disadvantages:

- Very sensitive to frequency sync., Phase noise.
- Sensitive to Doppler shift.
- Guard interval required to minimize effects of ISI/ICI.
- High peak-to-average power ratio (PAPR).

Figure-8 LTE OFDM Spectrum

2. LTE Physical Layer

- MIMO:
  - Refers to the use of multiple antennas at transmitter and/or receiver side
  - Classical configuration with 2 Tx and 2Rx antennas, 4 Tx antennas are also supported
  - Modes of operation of multiple transmit antennas:

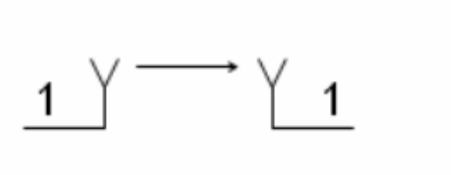
1. Transmit diversity (TxD):

   Combat fading + Replicas of the same signal + Get a higher SNR at the Rx

2. Spatial multiplexing (SM)

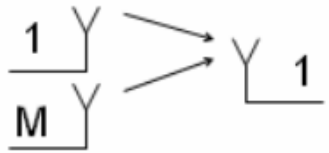
   Different streams simultaneously on different antennas + Higher data rate + No diversity gain

3. Beamforming



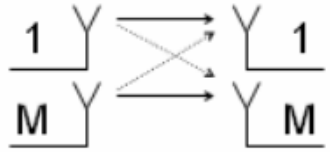
SISO

Single Input Single Output



MISO

Multiple Input Single Output

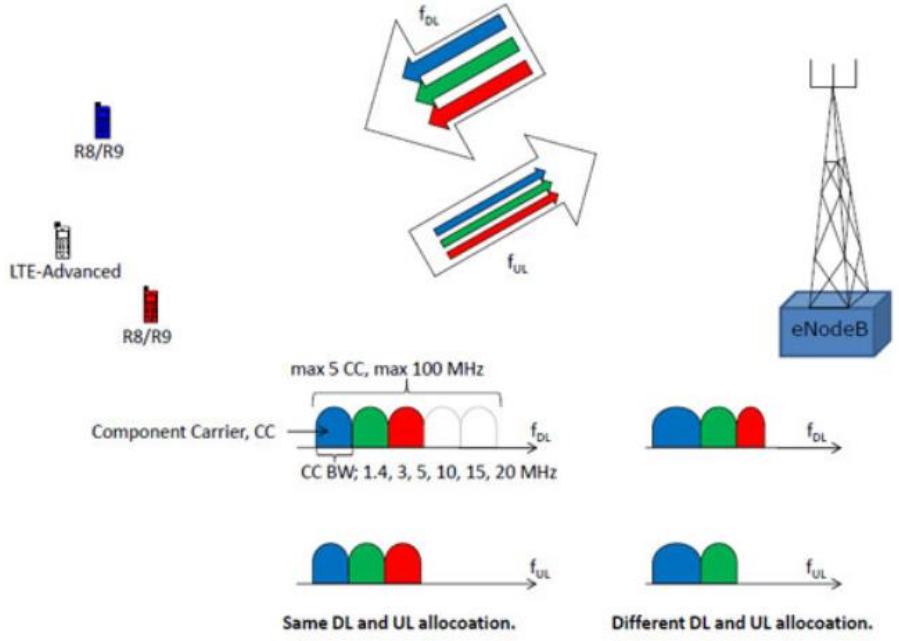


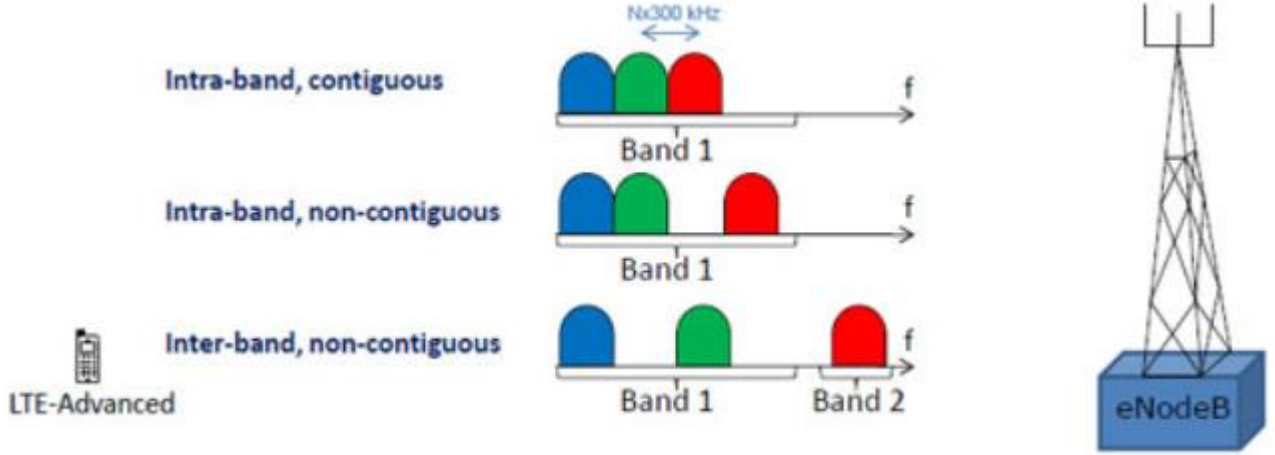
MIMO

Multiple Input Multiple Output

2. LTE Physical Layer

- Carrier Aggregation(CA)
  - CA is used in LTE-Advanced to increase the bandwidth, and thereby increase the bitrate.
  - Since it is important to keep backward compatibility with R8 and R9 UEs the aggregation is based on R8/R9 carriers.
  - Carrier aggregation can be used for both FDD and TDD.





2. LTE Physical Layer

- Carrier Aggregation(CA)

Carrier Aggregation bands in 3GPP Rel-12

Inter-band CA (2DL/1UL):

CA Band	E-UTRA operating band	Requested by
CA_1-3	1 + 3	China Unicom, China Telecom
CA_1-7	1 + 7	LGU +
CA_1-8	1 + 8	Softbank
CA_1-11	1 + 11	Softbank
CA_1-18	1 + 18	KDDI
CA_1-26	1 + 26	KDDI
CA_2-4	2 + 4	TMO-US
CA_2-5	2 + 5	AT&T
CA_2-12	2 + 12	US Cellular
CA_2-13	2 + 13	Verizon
CA_3-19	3 + 19	NTT DOCOMO
CA_3-20	3 + 20	Telekom Austria
CA_3-26	3 + 26	KT
CA_3-27	3 + 27	KT
CA_3-28	3 + 28	eAccess
CA_4-12	4 + 12	TMO-US
CA_4-27	4 + 27	NII Holdings
CA_5-7	5 + 7	LG Uplus
CA_5-25	5 + 25	US Cellular
CA_7-20	7 + 20	Telekom Austria
CA_7-28	7 + 28	Telefonica
CA_8-11	8 + 11	Softbank
CA_8-20	8 + 20	Vodafone
CA_12-25	12 + 25	US Cellular
CA_19-21	19 + 21	NTT DOCOMO
CA_20-32	20 + 32 (in UTRA BI + BXXXII)	Orange
CA_23-29	23 + 29	Dish
CA_39-41	39 + 41	CMCC
CA_41-42	41 + 42	China Unicom, China Telecom

Carrier Aggregation bands in 3GPP Rel-12

Intra-band contiguous CA:

CA Band	E-UTRA operating band	Requested by
CA_C_B3	3 (2DL/2UL)	Chin Unicom
CA_C_B7	7 (2DL/2UL)	Orange
CA_C_B23	23 (2DL/1UL)	Dish
CA_C_B27	27 (2DL/1UL)	NII Holdings
CA_C_B39	39 (2DL/2UL)	CMCC
CA_C_B40	40 (3DL/1UL)	CMCC
CA_C_B42	42 (2DL/2UL)	CMCC, NII, Bollore

Intra-band DL non-contiguous CA:

CA Band	E-UTRA operating band	Requested by
CA_NC_B2	2 (2DL/1UL)	Verizon
CA_NC_B3	3 (2DL/1UL)	SK Telecom
CA_NC_B4	4 (2DL/1UL)	TMO-US
CA_NC_B7	7 (2DL/1UL)	Telecom Italia
CA_NC_B23	23 (2DL/1UL)	Dish
CA_NC_B25	25 (2DL/1UL)	Telus
CA_NC_B42	42 (2DL/1UL)	CMCC, NII, Bollore

Inter-band TDD-FDD CA (2DL/1UL):

CA Band	E-UTRA operating band	Requested by
CA_8-40	8 + 40	KT
CA_1-42	1 + 42	NTT DOCOMO
CA_19-42	19 + 42	NTT DOCOMO

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4. LTE RF Conformance

3. LTE Radio Frequency:

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}	
1	1920 MHz – 1980 MHz	2110 MHz – 2170 MHz	FDD
2	1850 MHz – 1910 MHz	1930 MHz – 1990 MHz	FDD
3	1710 MHz – 1785 MHz	1805 MHz – 1880 MHz	FDD
4	1710 MHz – 1755 MHz	2110 MHz – 2155 MHz	FDD
5	824 MHz – 849 MHz	869 MHz – 894MHz	FDD
6	830 MHz – 840 MHz	875 MHz – 885 MHz	FDD
7	2500 MHz – 2570 MHz	2620 MHz – 2690 MHz	FDD
8	880 MHz – 915 MHz	925 MHz – 960 MHz	FDD
9	1749.9 MHz – 1784.9 MHz	1844.9 MHz – 1879.9 MHz	FDD
10	1710 MHz – 1770 MHz	2110 MHz – 2170 MHz	FDD
11	1427.9 MHz – 1447.9 MHz	1475.9 MHz – 1495.9 MHz	FDD
12	699 MHz – 716 MHz	729 MHz – 746 MHz	FDD
13	777 MHz – 787 MHz	746 MHz – 756 MHz	FDD
14	788 MHz – 798 MHz	758 MHz – 768 MHz	FDD
15	Reserved	Reserved	FDD
16	Reserved	Reserved	FDD
17	704 MHz – 716 MHz	734 MHz – 746 MHz	FDD
18	815 MHz – 830 MHz	860 MHz – 875 MHz	FDD
19	830 MHz – 845 MHz	875 MHz – 890 MHz	FDD
20	832 MHz – 862 MHz	791 MHz – 821 MHz	FDD

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}	
21	1447.9 MHz – 1462.9 MHz	1495.9 MHz – 1510.9 MHz	FDD
22	3410 MHz – 3490 MHz	3510 MHz – 3590 MHz	FDD
23	2000 MHz – 2020 MHz	2180 MHz – 2200 MHz	FDD
24	1626.5 MHz – 1660.5 MHz	1525 MHz – 1559 MHz	FDD
25	1850 MHz – 1915 MHz	1930 MHz – 1995 MHz	FDD
26	814 MHz – 849 MHz	859 MHz – 894 MHz	FDD
27	807 MHz – 824 MHz	852 MHz – 869 MHz	FDD
28	703 MHz – 748 MHz	758 MHz – 803 MHz	FDD
29	N/A	717 MHz – 728 MHz	FDD
30	2305 MHz – 2315 MHz	2350 MHz – 2360 MHz	FDD
31	452.5 MHz – 457.5 MHz	462.5 MHz – 467.5 MHz	FDD
32	N/A	1452 MHz – 1496 MHz	FDD
…			
64	Reserved		
65	1920 MHz – 2010 MHz	2110 MHz – 2200 MHz	FDD
66	1710 MHz – 1780 MHz	2110 MHz – 2200 MHz	FDD
67	N/A	738 MHz – 758 MHz	FDD
68	698 MHz – 728 MHz	753 MHz – 783 MHz	FDD

3. LTE Radio Frequency:

E-UTRA Operating Band	Uplink (UL) operating band BS receive UE transmit F_{UL_low} – F_{UL_high}	Downlink (DL) operating band BS transmit UE receive F_{DL_low} – F_{DL_high}	Duplex Mode
33	1900 MHz – 1920 MHz	1900 MHz – 1920 MHz	TDD
34	2010 MHz – 2025 MHz	2010 MHz – 2025 MHz	TDD
35	1850 MHz – 1910 MHz	1850 MHz – 1910 MHz	TDD
36	1930 MHz – 1990 MHz	1930 MHz – 1990 MHz	TDD
37	1910 MHz – 1930 MHz	1910 MHz – 1930 MHz	TDD
38	2570 MHz – 2620 MHz	2570 MHz – 2620 MHz	TDD
39	1880 MHz – 1920 MHz	1880 MHz – 1920 MHz	TDD
40	2300 MHz – 2400 MHz	2300 MHz – 2400 MHz	TDD
41	2496 MHz 2690 MHz	2496 MHz 2690 MHz	TDD
42	3400 MHz – 3600 MHz	3400 MHz – 3600 MHz	TDD
43	3600 MHz – 3800 MHz	3600 MHz – 3800 MHz	TDD
44	703 MHz – 803 MHz	703 MHz – 803 MHz	TDD
45	1447 MHz – 1467 MHz	1447 MHz – 1467 MHz	TDD
46	5150 MHz – 5925 MHz	5150 MHz – 5925 MHz	TDD

Index	Operator	Country	Frequency band
1	Aero2	Poland	Band38 2.6GHz
2	Mobily	Saudi Arabia	Band38 2.6GHz
3	STC	Saudi Arabia	Band40 2.3GHz
4	SKY Brasil Services	Brazil	Band38 2.6GHz
5	Softbank	Japan	Band41 2.6GHz
6	NBN	Australia	Band40 2.3GHz
7	Bharti Airtel	India	Band40 2.3GHz
8	Hi3G	Sweden	Band38 2.6GHz
9	UK Broadband	UK	Band42,43 3.5GHz
10	Omantel	Oman	Band40 2.3GHz

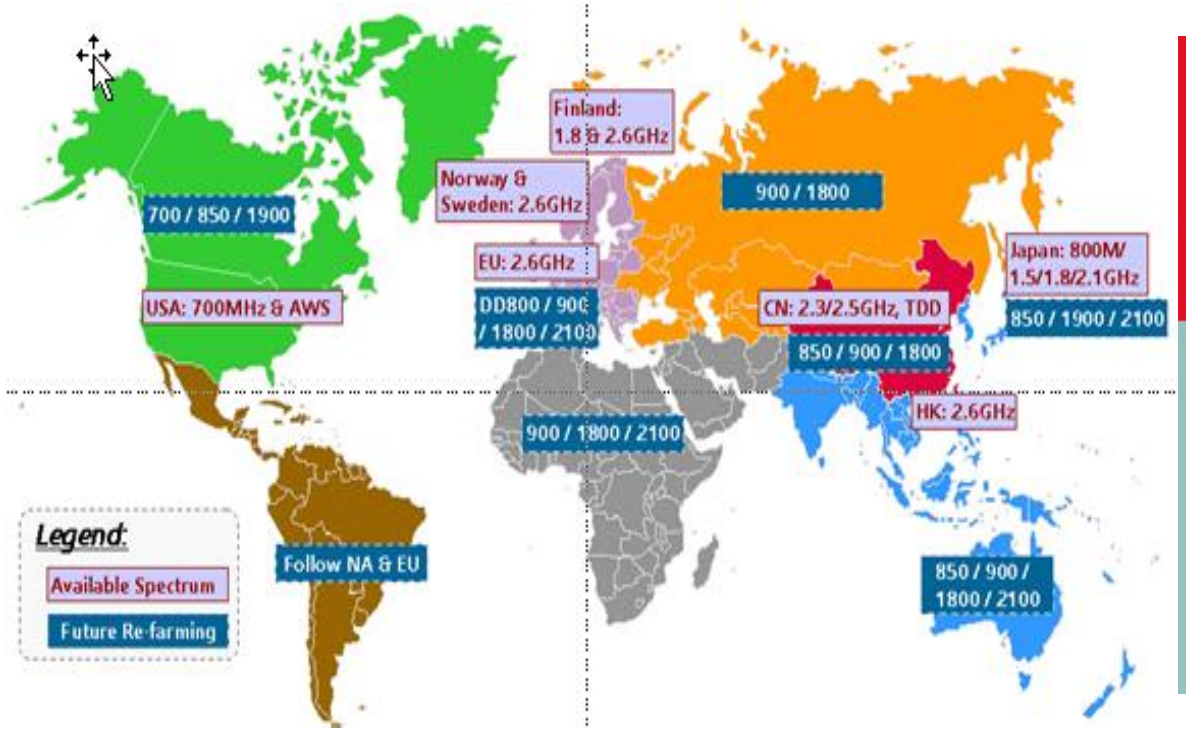
3. LTE Radio Frequency:

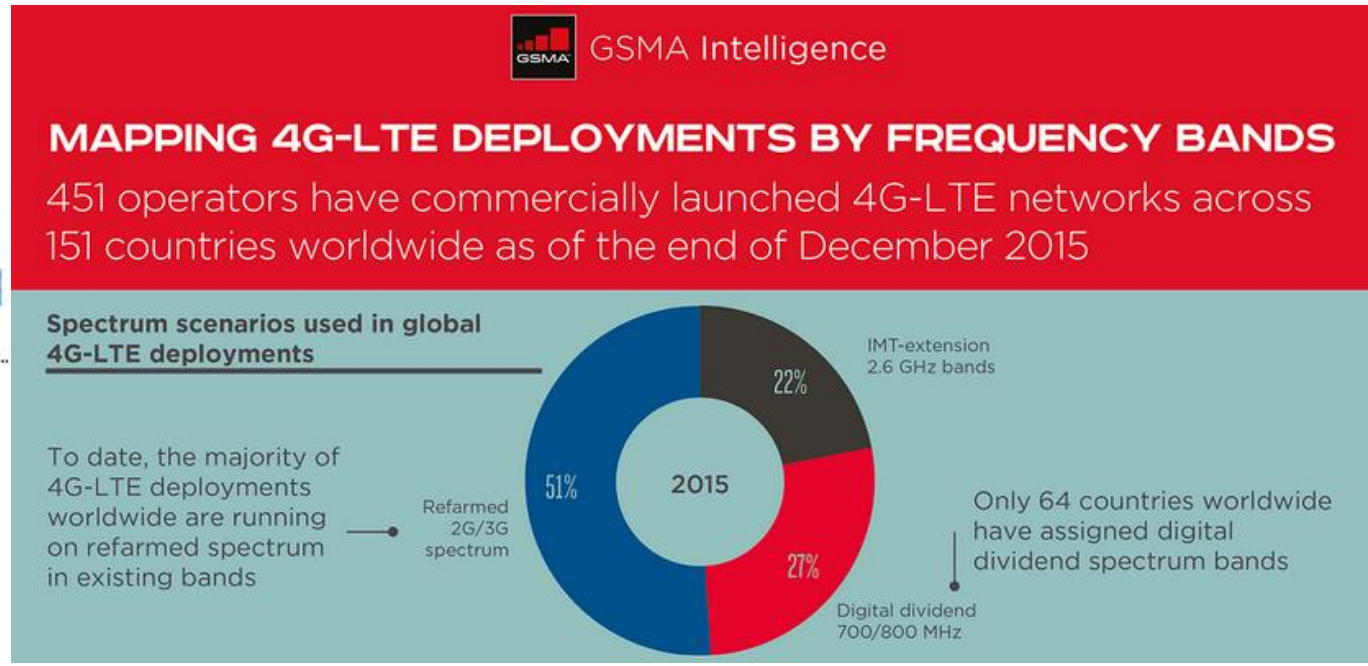
- EARFCN:
  - EARFCN stands for E-UTRA Absolute Radio Frequency Channel Number.
  - EARFCN number is within range 0 to 65535 and equation between LTE carrier frequency (MHz) and EARFCN is mentioned below.

$F_{downlink} = F_{DL\_Low} + 0.1 (N_{DL} - N_{DL\_Offset})$
$F_{uplink} = F_{UL\_Low} + 0.1 (N_{UL} - N_{UL\_Offset})$
Where,
N_{DL} is downlink EARFCN
N_{UL} is uplink EARFCN
N_{DL_Offset} is offset used to calculate downlink EARFCN
N_{UL_Offset} is offset used to calculate uplink EARFCN

E-UTRA Operating Band	Downlink			Uplink		
	F_{DL_low} (MHz)	$N_{Offs-DL}$	Range of N_{DL}	F_{UL_low} (MHz)	$N_{Offs-UL}$	Range of N_{UL}
1	2110	0	0 – 599	1920	18000	18000 – 18599
2	1930	600	600 - 1199	1850	18600	18600 – 19199
3	1805	1200	1200 – 1949	1710	19200	19200 – 19949
4	2110	1950	1950 – 2399	1710	19950	19950 – 20399
5	869	2400	2400 – 2649	824	20400	20400 – 20649
6	875	2650	2650 – 2749	830	20650	20650 – 20749
7	2620	2750	2750 – 3449	2500	20750	20750 – 21449
8	925	3450	3450 – 3799	880	21450	21450 – 21799

3. LTE Radio Frequency:





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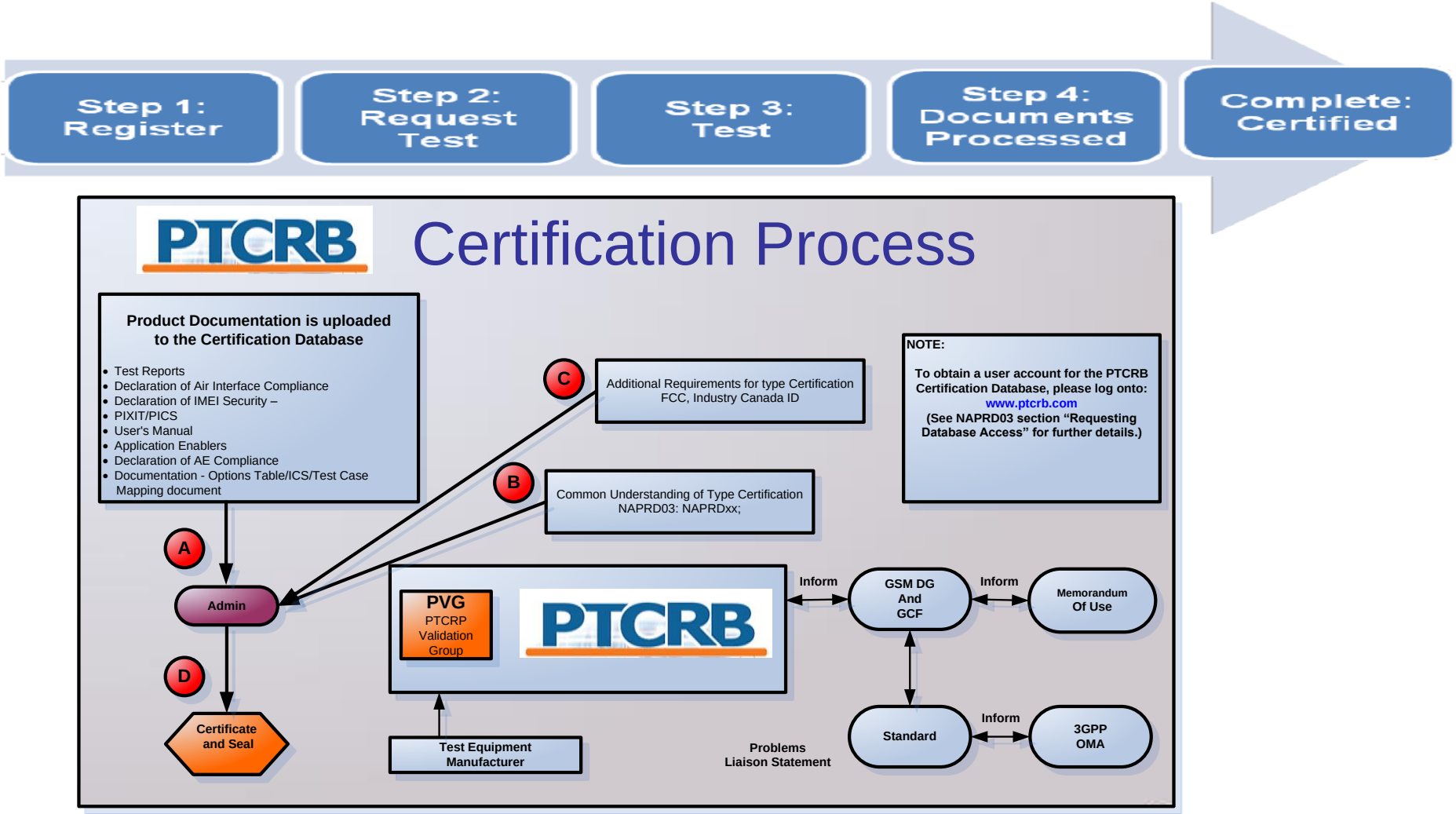
4. LTE RF Conformance:

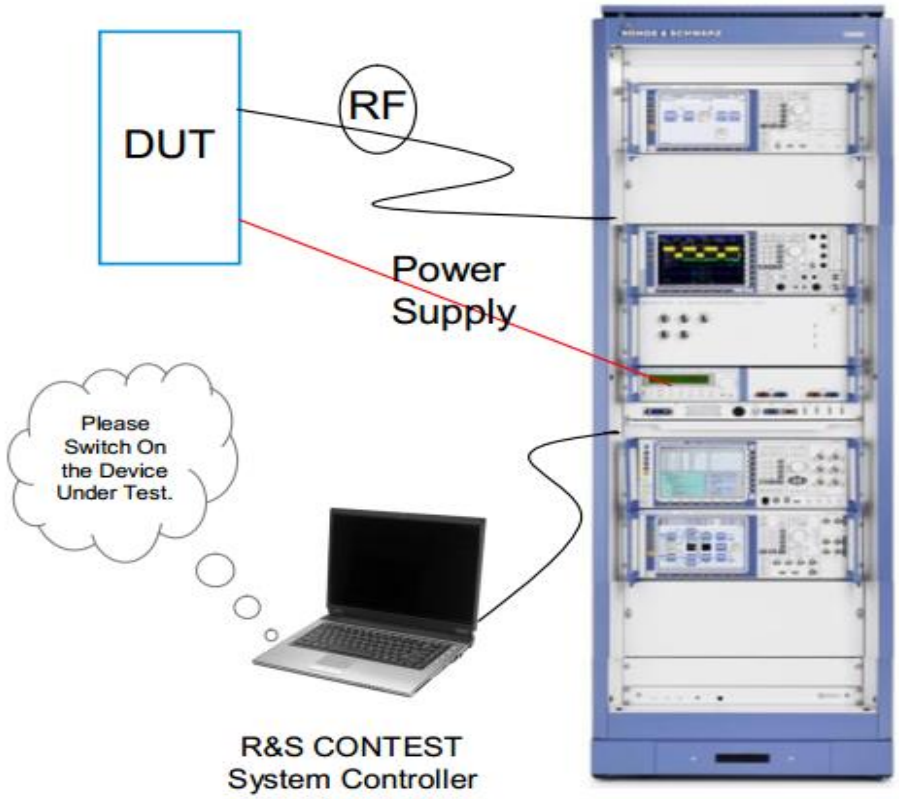
- Conformance testing is adopted to determine whether a product or system complies with the requirements of a specification or regulation.
- Towards a conformance proof, various test procedures and test setups have been developed specifically for testing conformance to standards.
- Conformance testing is performed preferably by independent organizations, which may be the standards body itself, to give sound assurance of compliance.

4. LTE RF Conformance:

- 

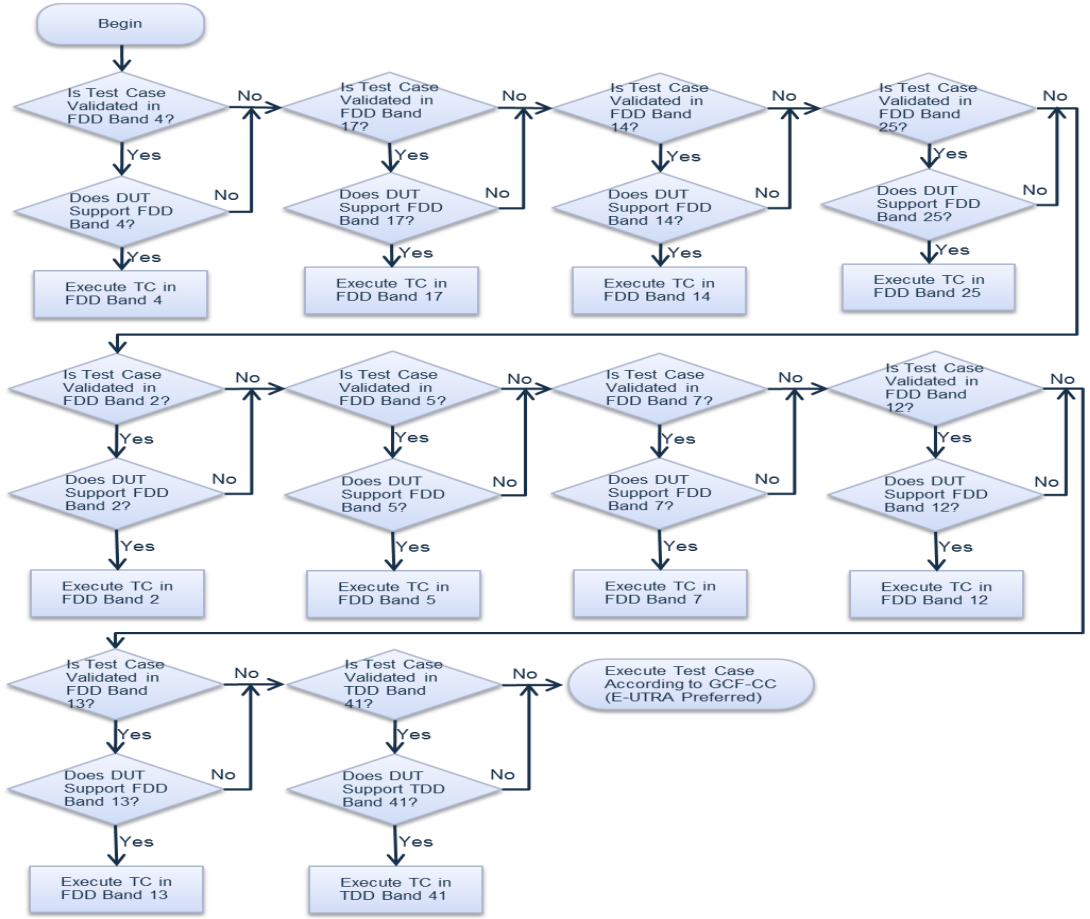
4. LTE RF Conformance:

- LTE UE RF Conformance Tests could been divided into 3 sub-categories:
  - RF Transmitter tests;
  - RF Receiver tests;
  - RF Performance tests.



4. LTE RF Conformance:

- Band & BW Selection



FDD 4 ⌄ FDD 17 ⌄ FDD 14 ⌄ FDD 25 ⌄ FDD 2 ⌄ FDD 5 ⌄ FDD 7 ⌄ FDD 12 ⌄

FDD 13 ⌄ FDD 41 ⌄ FDD 1

4. LTE RF Conformance:

- Band & BW Selection

E-UTRA band / channel bandwidth						
E-UTRA Band	1.4 MHz	3 MHz	5 MHz	10 MHz	15 MHz	20 MHz
2			Yes	Yes	Yes	Yes
4			Yes	Yes	Yes	Yes
5			Yes	Yes		
7			Yes	Yes		Yes
12			Yes	Yes		
13			Yes	Yes		
14			Yes	Yes		
17			Yes	Yes		
25			Yes	Yes		
41			Yes			Yes

4. LTE RF Conformance:

- Conformance Specification

TS No.	Title
TS 36.508	Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Packet Core (EPC); Common test environments for User Equipment (UE) conformance testing
TS 36.509	Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Packet Core (EPC); Special conformance testing functions for User Equipment (UE)
TS 36.521-1	Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) conformance specification; Radio transmission and reception; Part 1: Conformance testing
TS 36.521-2	Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) conformance specification; Radio transmission and reception; Part 2: Implementation Conformance Statement (ICS)
TS 36.521-3	Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) conformance specification; Radio transmission and reception; Part 3: Radio Resource Management (RRM) conformance testing
TR 36.903	Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Derivation of test tolerances for Radio Resource Management (RRM) conformance tests
TR 36.904	Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Derivation of test tolerances for User Equipment (UE) radio reception conformance tests
TR 36.905	Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Derivation of test points for radio transmission and reception conformance test cases

4. LTE RF Conformance:

- RF TX Tests: 1/2

Test Case	Specification/Limit
UE Maximum output power	Measured as the mean power in one sub-frame , **+23 dBm with +/- 2 dB** tolerance for LTE UE power class-3 devices for E-UTRA band 1 to 40 (Ref: section 6.2.2)
Maximum power reduction(MPR)	This test applies to all types of E-UTRA UE release 8 and forward. For UE Power Class 3, the allowed MPR values for the maximum output power is as follows. For QPSK for difference bandwidths(1.4,3,5,10,15,20) MPR is **<= 1dB** For 16QAM for above bandwidths there are two limits i.e. **<=1 dB** and **<=2 dB** as per RBs allocated. (Ref.section: 6.2.3)
Power control	Power control helps to limit the interference level and is useful to compensate the channel fading. There are three different specifications in this test case viz. Power control **absolute power** tolerance (**+/-9 dB** under normal conditions and **+/-12 dB** under extreme conditions) , power control relative power tolerance and Aggregate power control tolerance. (Ref. section: 6.3.5)
Minimum output power	Measured as the mean power in one sub-frame (i.e. 1ms) **-40 dBm** for difference channel bandwidths(1.4/3/5/10/15/20 MHz) ,(Ref. section:6.3.2)

Test Case	Specification/Limit
Transmit OFF Power	The LTE UE Transmit OFF power is defined as the mean power when the transmitter is OFF. During frame measurements gaps, the UE is not considered to be OFF. The transmitter is considered to be OFF when the UE is not allowed to transmit or during periods when the UE is not transmitting a LTE subframe. It is **-48.5 dBm** for various channel BW/measurement BW combinations. (1.4MHz/1.08MHz, 3MHz/2.7MHz, 5MHz/4.5MHz, 10MHz/9MHz, 15MHz/13.5MHz, 20MHz/18MHz) (section: 6.3.3)
Frequency error	**+/- 0.1 ppm** observed over a period of one time slot (0.5 ms) compared to the carrier frequency received from the LTE eNodeB or base station. (section:6.5.1)
Min. Transmit Error Vector Magnitude(EVM) -	It should not exceed values listed below. For **BPSK/QPSK**: **17.5 dB** (Average level), 17.5 dB(Ref.signal EVM level) For **16QAM**: **12.5 dB**(Average level), 12.5 dB (Ref.signal EVM level) EVM measurements are evaluated for 10 consecutive uplink sub-frames for the average EVM case,and 60 consecutive sub-frames for the reference signal EVM case. (section: 6.5.2).
Occupied Bandwidth	It is defined as the bandwidth containing 99% of the total integrated mean power of the transmitted spectrum on the assigned channel. Occupied bandwidth is the most fundamental LTE spectral emissions measurement. It should be **less than** values for different channel BWs as follows. **1.4MHz (for 1.4MHz channel BW)**,3MHz (for 3MHz channel BW), 5, 10, 15, 20 MHz. (section:6.6.1)

4. LTE RF Conformance:

- RF TX Tests: 2/2

Test Case	Specification/Limit
Spectrum Emission Mask	The spectrum emission mask defines **maximum power** that the transmitter **can emit** in a defined bandwidth at a range of frequency offsets from the center channel. Frequency offsets ranging from 1 MHz to 25 MHz from the band edge is used for this **LTE device testing**. It uses a measurement bandwidth of 1 MHz. The spectrum emission values have been defined for different channel bandwidths (1.4/3 /5/10/15/20 MHz). Close in measurements need to be measured with 30 KHz measurement BW. (section: 6.6.2.1)
ACLR (Adjacent channel leakage power ratio)	This test case is used to verify that UE transmitter does not cause unacceptable interference to adjacent channels in terms of Adjacent Channel Leakage power Ratio(ACLR). E-UTRA ACLR = (power in the center E-UTRA channel)/(power in an adjacent E-UTRA channel) The ACLR value is **30 dB** for different channel BW/measurement BW combinations (1.4 MHz /1.08 MHz, 3 MHz/2.7 MHz, 5/4.5, 10/9, 15/13.5, 20 MHz/18 MHz) . (section:6.6.2.3)

Transmitter spurious emissions	spurious emission limits for various frequency ranges and measurement bandwidths are as follows:
	For (9KHz<=f<150KHz and 1 KHz) is **-36 dBm**
	For (150KHz<=f<30 MHz and 10 KHz) is -36 dBm
	For (30 MHz<=f<1000 KHz and 100 KHz) is -36 dBm
	For (1GHz<=f<12.75 GHz and 1 MHz) is **-30 dBm**
	(section: 6.6.3.1)

Test Case	Specification/Limit
Transmit intermodulation	The transmit intermodulation performance is a measure of the capability of the transmitter to inhibit the generation of signals in its non linear elements caused by presence of the wanted signal and an interfering signal reaching the transmitter via the antenna. The UE intermodulation attenuation is defined by the ratio of the mean power of the wanted signal to the mean power of the intermodulation product when an interfering CW signal is added at a level below the wanted signal at each of the transmitter antenna port with the other antenna port(s) if any is terminated. BW channel (Uplink): 20 MHz Interference signal frequency offset: 20 MHz, 40 MHz Interference CW signal level: -40dBc Intermodulation product: **-35dBc** Measurement bandwidth: 18 MHz Refer Table 6.7.3-1 in section:6.7 for other channel BWs

4. LTE RF Conformance:

- TX Max. Output Power: Class 3 23dBm ±2.7dB

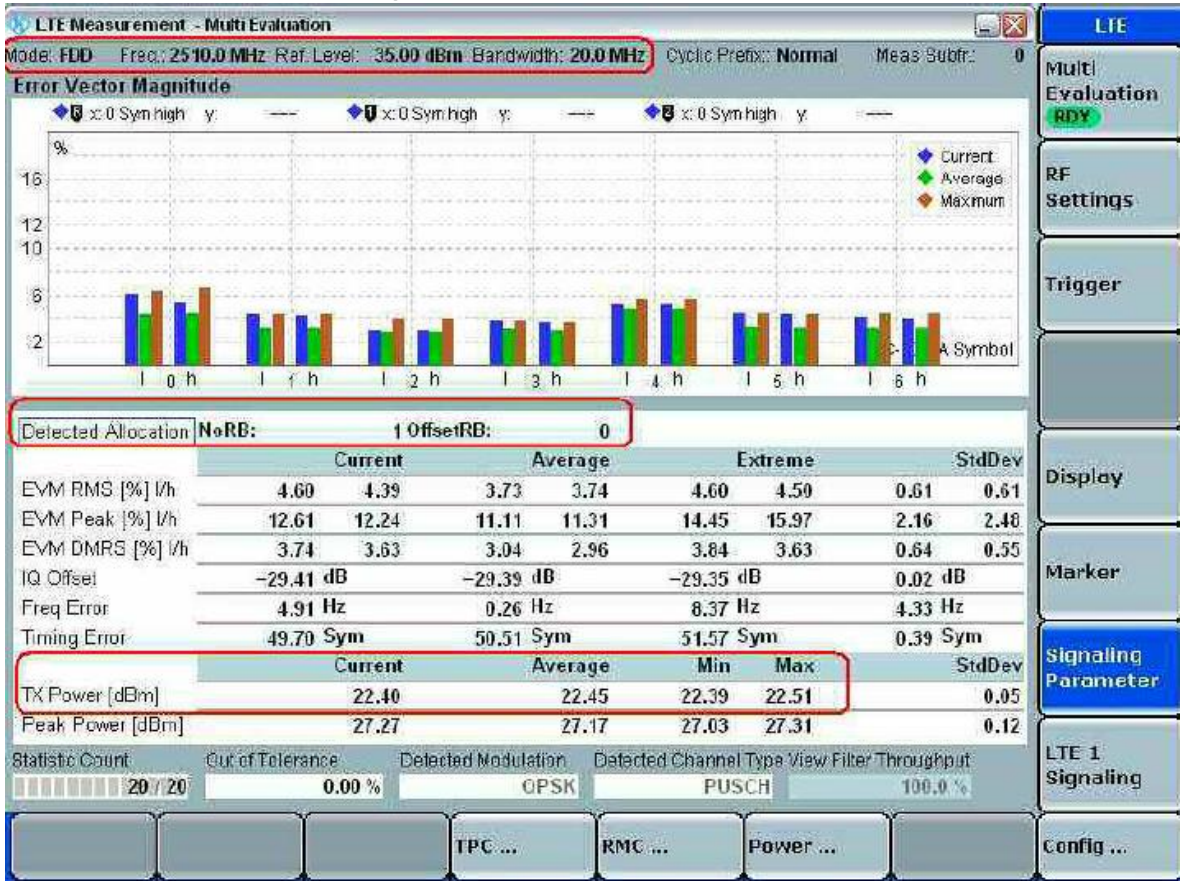
This test is for verifying that the error for the UE maximum output power does not exceed the range prescribed by the specified nominal maximum output power and tolerance.

An excessively high maximum output power could interfere with other channels or systems.

Insufficient maximum power would decrease the coverage area.

4. LTE RF Conformance:

- TX Max. Output Power: Class 3 23dBm ±2.7dB



EUTRA band	Class 1 (dBm)	Tolerance (dB)	Class 2 (dBm)	Tolerance (dB)	Class 3 (dBm)	Tolerance (dB)
1					23	±2.7
2					23	±2.7[2]
3					23	±2.7[2]
4					23	±2.7
5					23	±2.7
6					23	±2.7
7					23	±2.7[2]
8					23	±2.7[2]
9					23	±2.7
10					23	±2.7

Modulation	Channel bandwidth / Transmission bandwidth configuration [RB]						MPR (dB)
	1.4 MHz	3.0 MHz	5 MHz	10 MHz	15 MHz	20 MHz	
QPSK	> 5	> 4	> 8	> 12	> 16	> 18	≤ 1
16 QAM	≤ 5	≤ 4	≤ 8	≤ 12	≤ 16	≤ 18	≤ 1
16 QAM	> 5	> 4	> 8	> 12	> 16	> 18	≤ 2

4. LTE RF Conformance:

- RF RX Tests:

Test Case	3GPP TS 36.521 description
Reference sensitivity level	There are different levels specified for various E-UTRA bands for different channel BWs and duplex modes(FDD/TDD) as specified in the standard. For example: For EUTRA **band 44, TDD mode**: -100.2 dBm (3 MHz) , -98(5 MHz), -95(10 MHz), -93.2(15 MHz), **-92 dBm (20 MHz)** (section 7.3)
Maximum input level	The minimum conformance requirements for maximum input level necessitates that the receiver be able to achieve at least 95% of the maximum throughput in the presence of signal powers up to **-25 dBm** (for various channel BWs) . (section: 7.4)
Adjacent channel selectivity	LTE receiver Adjacent Channel Selectivity(ACS) for different transmission BWs are as follows. ACS is 33 dB (for 1.4/3/5/10 MHz), 30 dB for 15 MHz and 27 dB for 20 MHz. (section 7.5)
In-band blocking	The blocking characteristic is a measure of the receiver's ability to appropriately demodulate LTE signals in the presence of a wide range of interference signals. In-band blocking is a metric of receiver performance in the presence of unwanted interfering signal falling into the UE receive band, or into the first 15 MHz below or above the UE receive band. (section 7.6.1)
Out-of-band blocking	The LTE receiver out-of-band band blocking characteristics are designed as a metric to evaluate receiver performance in the presence of higher power out-of band signals. Unlike the in-band blocking characteristics that use a modulated signal, the out-of-band interfering signal is a continuous wave (CW) signal. (section 7.6.2)

Test Case	3GPP TS 36.521 description
Narrow band blocking	Narrowband blocking is a metric of the LTE receiver's ability achieve minimum throughout in the presence of an unwanted narrow band interferer at a frequency offset that is less than the channel spacing. Similar to the out-ofband blocking characteristics, the narrowband blocking measurement requires a test configuration that uses both a vector signal generator and a CW signal generator. (section 7.6.3)
Spurious response	Narrowband blocking is a metric of the LTE receiver's ability achieve minimum throughout in the presence of an unwanted narrow band interferer at a frequency offset that is less than the channel spacing. Similar to the out-ofband blocking characteristics, the narrowband blocking measurement requires a test configuration that uses both a vector signal generator and a CW signal generator. (section 7.7)
Wide Band Intermodulation	Receiver intermodulation characteristics is a metric that describes the linearity of the receiver's front end. A receiver's resilience to intermodulation distortion is determined by injecting two interference signals in addition to a reference downlink LTE signal to the receiver. The frequency spacing of the two interfering signals is chosen such that they produce a third-order distortion product that directly interferes with the reference downlink signal. (section 7.8.1)
Spurious emissions	Unlike most receiver measurements, which define a receiver's ability to achieve a specified throughput under a range of signal conditions, the spurious emissions measurement is designed to characterize the receive port's radiated emissions. (section 7.9)

4. LTE RF Conformance:

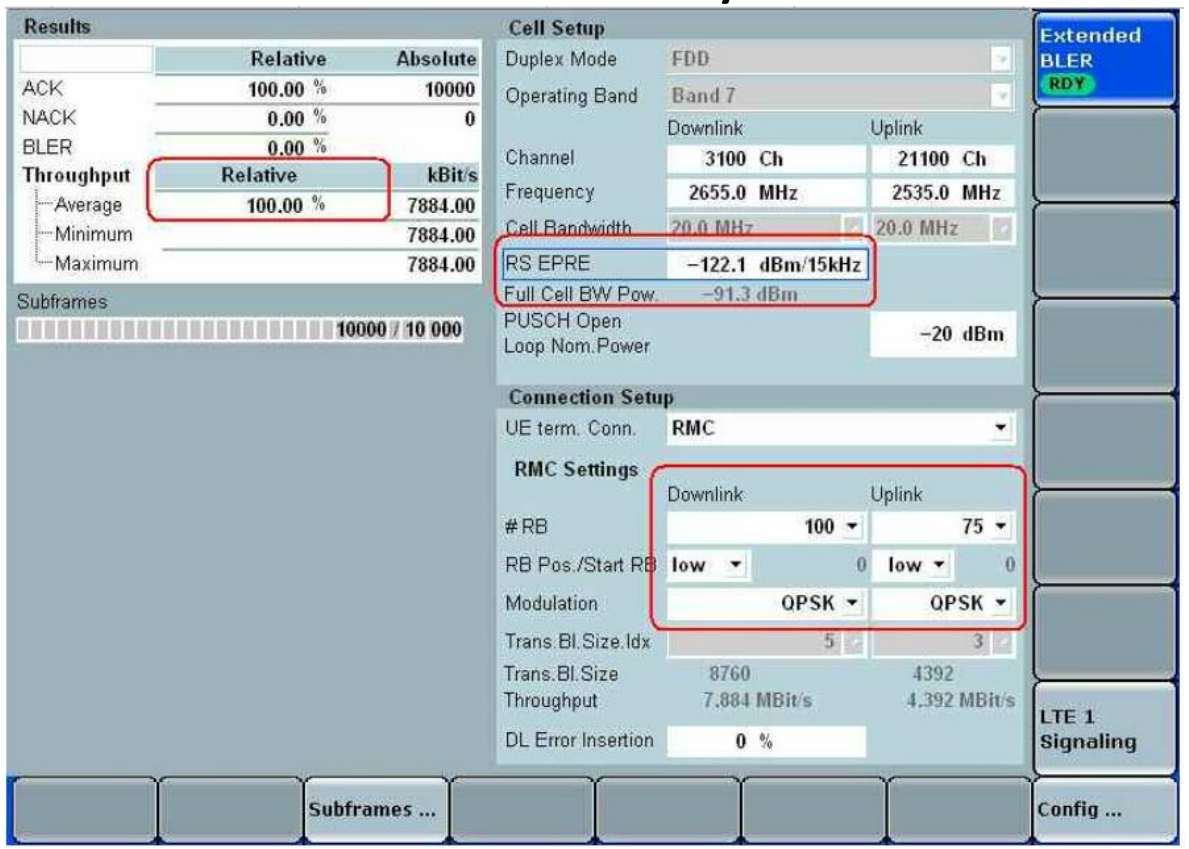
- RX Reference Sensitivity

The purpose of this test is to verify the UE's ability to receive data at a given average throughput for a specified reference measurement channel under conditions that involve a low signal level, ideal propagation and no added noise.
A UE that is unable to meet the throughput requirement under these conditions will decrease an e-NodeB's effective coverage area.

$$P_{REFSENS} = RS\ EPRE + 10 * \log10(N\_RE)$$

4. LTE RF Conformance:

- RX Reference Sensitivity



Reference sensitivity QPSK $P_{REFSENS}$

E-UTRA Band	Channel bandwidth 1.4 MHz (dBm)	3 MHz (dBm)	5 MHz (dBm)	10 MHz (dBm)	15 MHz (dBm)	20 MHz (dBm)	Duplex Mode
1	-	-	-100	-97	-95.2	-94	FDD
2	-102.7	-99.7	-98	-95	-93.2	-92	FDD
3	-101.7	-98.7	-97	-94	-92.2	-91	FDD
4	-104.7	-101.7	-100	-97	-95.2	-94	FDD
5	-103.2	-100.2	-98	-95			FDD
6	-	-	-100	-97			FDD
7	-	-	-98	-95	-93.2	-92	FDD
8	-102.2	-99.2	-97	-94			FDD
9	-	-	-99	-96	-94.2	-93	FDD

4. LTE RF Conformance:

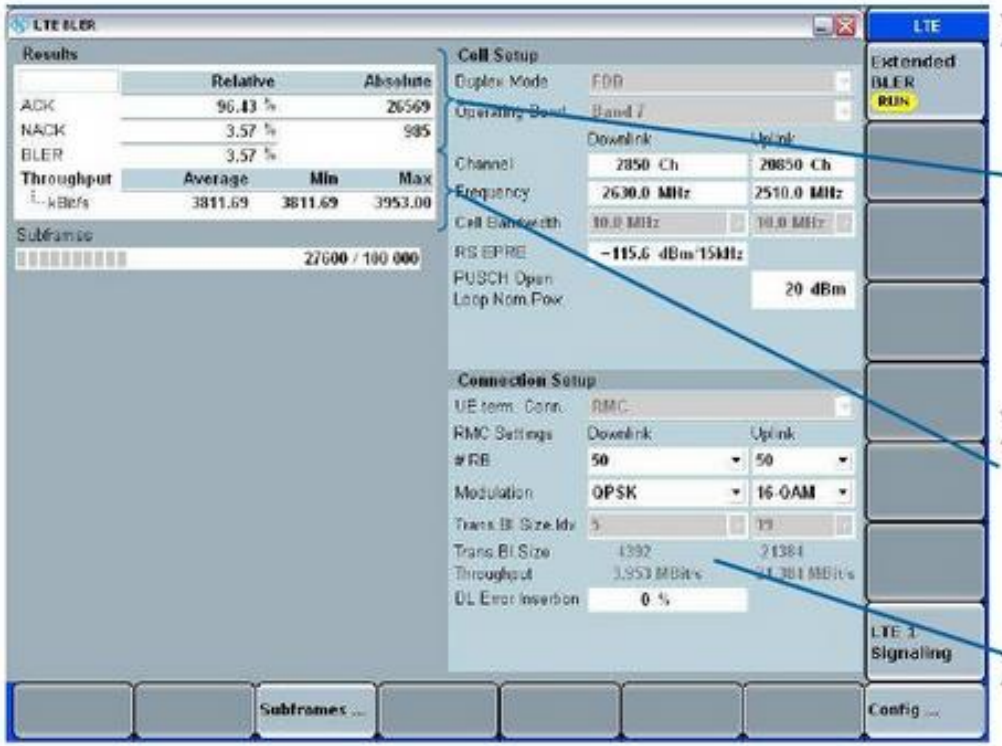
- RF Performance Tests:

Test Case	Standard reference/Description
PDSCH single antenna port performance	8.2.1.1(LTE,FDD) 8.2.2.1(LTE,TDD)
PDSCH Transmit diversity performance	8.2.1.2(LTE,FDD) 8.2.2.2(LTE,TDD)
PDSCH Open Loop spatial multiplexing performance	8.2.1.3(LTE,FDD) 8.2.2.3(LTE,TDD)
PDSCH closed loop spatial multiplexing performance	8.2.1.4(LTE,FDD) 8.2.2.4(LTE,TDD)
MU-MIMO	8.2.2.5
Control channel performance D-BCH PCH	8.2.2.6

Test Case	Standard reference/Description
Demodulation of PDSCH(User-Specific reference symbols)	8.3
PCFICH/PDCCH single antenna port performance	8.4.1.1(LTE,FDD) 8.4.2.1(LTE,TDD)
PCFICH/PDCCH transmit diversity performance	8.4.1.2 (LTE,FDD) 8.4.2.2(LTE,TDD)
Demodulation of PHICH	8.5
Demoduation of PBCH	8.6

4. LTE RF Conformance:

- DL Reference Channel Measurements:



- Rx Measurements
  - Counting
    - ACKnowledgement (ACK)
    - NonACKnowledgement (NACK)
- Calculating
  - BLER (NACK/ALL)
  - Throughput [kbps]
- Flexibility
  - Change paramters directly in the measurement “on the fly”

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Photo：

Thank You.

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