

4G/5G thresholds calculator

Release number v4.0

1. Introduction

This document describes how to use the **4G/5G thresholds calculator** tool.

There are different thresholds considered for 4G/5G planning, and the purpose of this tool is to calculate them based on different input parameters:

- **RSRP threshold:** it is used for best server and RS coverage display and during SNIR calculations to check if a point is covered or not. It is the balanced RSRP threshold, considering the min (max permissible path loss DL, UL) and is calculated from:
 - UE and eNodeB/gNodeB parameters (Power, Bandwidth, Tx and Rx gain including MIMO gain, Tx and Rx losses);
 - Network parameters (Probability to achieve, Standard deviation);
 - UL and DL parameters: SNIR required for throughput, Noise figure.

- **Coverage threshold:** this is the minimum field strength (or power received) on the UE from the eNodeB/gNodeB. It is set in the Threshold parameters box as the Global threshold, or Cov. threshold in station parameters (if mode "Threshold from stations" is set in Threshold parameters box). It is an **unbalanced threshold** and is calculated from:
 - Network parameters (Bandwidth, Probability to achieve, Standard deviation);
 - Downlink parameters: SNIR required for throughput, Noise figure.

- **Rx threshold:** this is the minimum field strength (or power received) on the eNodeB/gNodeB from the UE. It is set in the station parameters as Rx threshold. It is an **unbalanced threshold** and is calculated from:
 - Network parameters (Bandwidth, Probability to achieve, Standard deviation);
 - Uplink parameters: SNIR required for throughput, Noise figure.

- **Maximum permissible path loss (dB) downlink:** this is the Radio link budget for downlink. It is calculated from:
 - eNodeB/gNodeB parameters (power, Tx gain including MIMO gain and losses) and UE parameters (Rx gain including MIMO gain and losses);
 - Network parameters (Bandwidth, Probability to achieve, Standard deviation);
 - Downlink parameters: SNIR required for throughput, Noise figure.

- **Maximum permissible path loss (dB) uplink:** this is the Radio link budget for uplink. It is calculated from:
 - eNodeB/gNodeB parameters (Rx gain including MIMO gain and losses) and UE parameters (Power, Tx gain including MIMO gain and losses);
 - Network parameters (Bandwidth, Probability to achieve, Standard deviation);
 - Uplink parameters: SNIR required for throughput, Noise figure.

- **Minimum thresholds for planning DL / UL:** They are calculated from:
 - o UE and eNodeB//gNodeB parameters (Power, Tx and Rx gain including MIMO gain, Tx and Rx losses);
 - o Network parameters (Bandwidth, Probability to achieve, Standard deviation);
 - o UL and DL parameters: SNIR required for throughput, Noise figure.

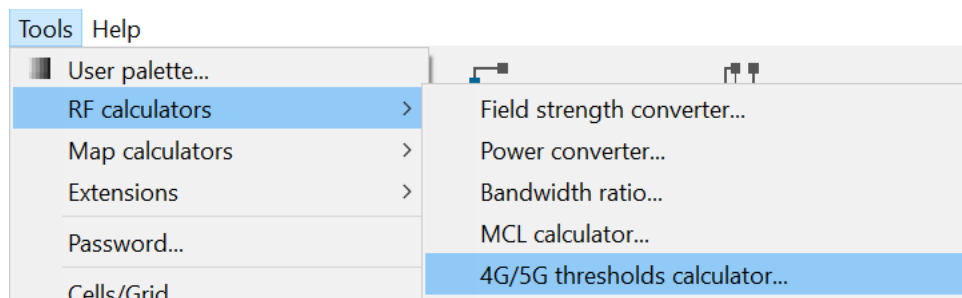
They are the **balanced threshold** use to check downlink and UL coverage with full power considered.

Reference frequency (MHz), minimum throughput required (kbps) and RSRQ required (dB) are not used in the calculations but will update the parameters in the simulation environment.

The **downlink KTBF, RSRP threshold and Planning thresholds (DL and UL) (if auto option is checked)** will also update the same parameters used in the different interference calculations (like SNIR or RSRP maps).

2. 4G/5G thresholds calculator

To open the calculator when a project is loaded, go to **Tools/RF calculators/4G/5G thresholds calculator...**



The following window will appear:

Item	Value	Item	eNodeB	UE
Reference frequency (MHz)	2600.000000	Transmit power / port (dBm)	43.0	23.0
Bandwidth (MHz)	10.000000	Tx gain (dB)	17.00	0.00
Probability to achieve (pc)	95.00 <small>0 = not used</small>	Rx gain (dB)	17.00	0.00
RSRQ required (dB)	-19	Tx losses (dB)	1.00	0.00
STDDEV / Slow fade margin (dB)	3.00 / 4.9	Rx losses (dB)	1.00	0.00
<input checked="" type="radio"/> TDD DL/UL ratio 54.29 <input type="radio"/> FDD PDSCH (pc) 84.32 4G...		Tx gain mimo (dB)*	3.01	0.00
Numerology: <input type="radio"/> 0 <input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4 <input checked="" type="radio"/> 5 <input checked="" type="radio"/> 4G		Rx gain mimo (dB)*	3.01	3.01
		<small>*only if not already included in Tx/Rx gains</small>		
Min throughput per user (kbps)	Downlink: 1000.0 Uplink: 1000.0	Max permissible pathloss (dB)	Downlink: 163.58 Uplink: 139.07	
RBs available	Downlink: 22 Uplink: 22	Balanced thresholds: DL/UL (dBm)	Downlink: -74.05 Uplink: -97.06	
SNIR required for throughput (dB)	Downlink: -4 Uplink: -2	<input type="checkbox"/> Assign balanced thresholds to activated eNodeB		
Noise figure (dB)	Downlink: 5.0 Uplink: 4.5	Strategy		
KTBF (dBm)	Downlink: -99.46 Uplink: -99.96	<input type="radio"/> User defined RBs <input type="radio"/> Lowest SNIR and min RBs <input checked="" type="radio"/> Available RBs		
Coverage / Rx thresholds (dBm)	Downlink: -98.56 Uplink: -97.06			
Min RSRP (dBm)	Downlink: -122.77 Apply			

Before using the calculator you need to fill information about the network configuration (Power, Gain including MIMO gain, Losses, Frequency, Bandwidth, Probability to achieve and Standard deviation) for eNodeB/gNodeB and User element:

Item	eNodeB	UE
Transmit power / port (dBm)	43.0	23.0
Tx gain (dB)	17.00	0.00
Rx gain (dB)	17.00	0.00
Tx losses (dB)	1.00	0.00
Rx losses (dB)	1.00	0.00
Tx gain mimo (dB)*	3.01	0.00
Rx gain mimo (dB)*	3.01	3.01

*only if not already included in Tx/Rx gains

Note: The Tx and Rx mimo gain values must be filled only if they are nit already included in the Tx and Rx gains.

Item	Value
Reference frequency (MHz)	2600.000000
Bandwidth (MHz)	10.0000000
Probability to achieve (pc)	95.00 <small>0 = not used</small>
RSRQ required (dB)	-19
STDDEV / Slow fade margin (dB)	3.00 / 4.9
	<input checked="" type="radio"/> TDD DL/UL ratio 54.29 <input type="radio"/> FDD PDSCH (pc) 84.32
Numerology:	<input type="radio"/> 0 <input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4 <input type="radio"/> 5 <input checked="" type="radio"/> 4G

And also the strategy:

Strategy

User defined RBs

Lowest SNIR and min RBs

Available RBs

RBs available	22	22
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"User defined RBs": Number of RBs used to compute the throughputs (DL and UL) are user defined.

"Lowest SNIR and min RBs": Try to find the minimum number of RBs required to achieve the expected throughputs and for the lowest SNIR values matching throughput requirements.

The RSRP threshold derived from the balanced DL threshold has also been added.

"Available RBs": All available RBs dedicated to PDSCH (traffic) are used to compute the throughputs (DL and UL). In that case, the required SNIR values will be minimized.

The calculator will then compute:

- **KTBF** of the receivers according to the noise figure and bandwidth:

Noise figure (dB)	5.0	4.5
KTBF (dBm)	-99.46	-99.96

- **Slow fading margin**: Computed according to **Probability to achieve** and **Standard deviation**:

Item	Value
Reference frequency (MHz)	2600.000000
Bandwidth (MHz)	10.0000000
Probability to achieve (pc)	95.00 <small>0 = not used</small>
RSRQ required (dB)	-19
STDDEV / Slow fade margin (dB)	3.00 / 4.9
<input checked="" type="radio"/> TDD DL/UL ratio 54.29 <input type="radio"/> FDD PDSCH (pc) 84.32	
Numerology: <input type="radio"/> 0 <input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4 <input checked="" type="radio"/> 4G	

- **Min RSRP**: Computed according to the **radiated power on the RS channel** and the **max permissible pathloss** (please refer to point 1. *Introduction* for definitions):

Coverage / Rx thresholds (dBm)	-98.56	-97.06
<input type="checkbox"/> Assign to activated eNodeB		
Min RSRP (dBm)	-122.77	Apply

- **Coverage / Rx threshold**: Computed according to Network parameters, SNIR and Noise figure (please refer to point 1. *Introduction* for definitions)

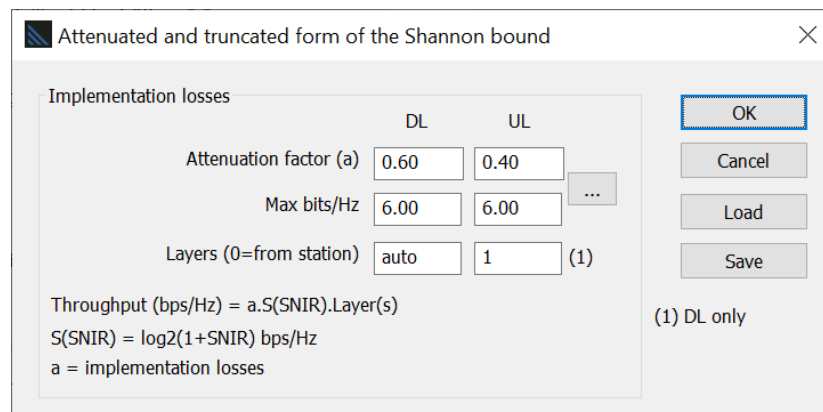
Assign to activated eNodeB: if checked, this option will update the KTBF, the coverage threshold and the Rx threshold of the activated stations.

Apply button will update the global RSRP coverage threshold value in the "Threshold" parameters box.

Item	Downlink	Uplink
Max permissible pathloss (dB)	163.58	139.07
Balanced thresholds: DL/UL (dBm)	-74.05	-97.06
<input type="checkbox"/> Assign balanced thresholds to activated eNodeB		

Assign balanced thresholds to activated eNodeB: If checked, this option will update the coverage and receiving thresholds parameters of the activated stations with the balanced values found.

- **SNIR vs Throughput...**: Access to the box “Attenuated and truncated form of the Shannon bound” (3GPP TR 36.942, “Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Frequency (RF) system scenarios”, <http://www.3gpp.org/ftp/Specs/html-info/36942.htm>).




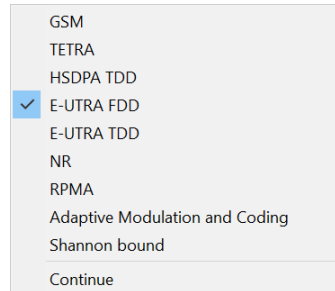
$S(\text{SNIR})$ = Shannon bound, which represents the maximum theoretical throughput that can be achieved over an AWGN (Additive White Gaussian Noise) channel with a given SNR.
 a = attenuation factor of the Shannon bound (implementation losses).

NOTES:

- $S(\text{SNIR}) = \log \text{base } 2 (1 + \text{SNIR}) \text{ bps/Hz.}$
- If the number of layers is set "from station parameters" (0), the number of layers will be extracted from each base station Tx arrays.
- The number of layers can be set in the station parameters (for MIMO antennas) in the "Patterns" tab and works as follows:
 - Example 1:
 Number of Tx/Rx arrays = 4
 Number of MIMO Layers = 1
 Number of antennas per MIMO Layer = $4/1 = 4$
 MIMO Gain = $10 \cdot \log(4) = 6\text{dB}$
 - Example 2:
 Number of Tx/Rx arrays = 4
 Number of MIMO Layers = 2
 Number of antennas per MIMO Layer = $4/2 = 2$
 MIMO Gain = $10 \cdot \log(2) = 3\text{dB}$
 - Example 3:

Number of Tx/Rx arrays = 64 (5G)
 Number of MIMO Layers = 8
 Number of antennas per MIMO Layer = $64/8 = 8$
 MIMO Gain = $10 \cdot \log(8) = 9\text{dB}$

- Click on the  button to access the recommended parameters for different technologies:



3. 4G/5G thresholds used in 4G/5G related functions

- **SNIR** is computed on the best server area if $\text{RSRP} \geq \text{RSRP threshold}$ and if FS or PR (full power) level \geq Global threshold or Station threshold (**Coverage threshold**).
- **RSRQ** is computed on a given point only if $\text{RSRP} \geq \text{RSRP threshold}$ and FS or PR (full power) level is greater than the coverage threshold.
- **Coverage threshold** is used for downlink FS calculations (Tx/Rx FS coverage) and SNIR calculations.
- **Rx threshold** is used for uplink FS calculations (Tx/Rx uplink FS coverage).