Link-level calibration results

The following document provides the specific calibration results that were performed for the link-level simulator. It describes the calibration procedure performed to demonstrate the correct operation of the link-level simulator employed in the Evaluation Report from the 5G Infrastructure Association on the IMT-2020 proposal.

The calibration results are obtained for 5G New Radio PDSCH (Physical Downlink Shared Channel) and PUSCH (Physical Uplink Shared Channel).

I PDSCH methodology and parameter configuration

The calibration procedure is fully aligned with the evaluation process followed in 3GPP RAN WG4. As described in [1], 3GPP calibrates the PDSCH performance by evaluating the maximum throughput provided for FR1 and FR2 scenarios and FDD and TDD techniques. For each frequency range and duplexing technique, a specific set of cases is described. Calibration is here performed for FR1 and FDD.

As shown in Table 1, 3GPP defines up to fourteen different evaluation cases for this combination. Different channel models, MCS indexes and MIMO configurations are considered. For the sake of simplicity, the calibration is here provided for cases 4 and 5.

Case Number	BW/ SCS	MIMO	PDSCH mapping and MCS	Layers	Channel Model
1	10MHz/15kHz	2Tx 2Rx ULA Low 2Tx 4Rx ULA Low	Type A QPSK MCS 4	1	TDL-B 100ns, 400Hz
2	10MHz/15kHz	2Tx 2Rx ULA Low 2Tx 4Rx ULA Low	Type A QPSK MCS 4	1	TDL-C 300ns, 100Hz
3	10MHz/15kHz	2Tx 2Rx ULA Low 2Tx 4Rx ULA Low	Type A 256QAM MCS 24	1	TDL-A 30ns, 10Hz
4	10MHz/15kHz	2Tx 2Rx ULA Low 2Tx 4Rx ULA Low	Type A 16QAM MCS 13	2	TDL-C 300ns, 100Hz
5	10MHz/15kHz	2Tx 2Rx ULA Low 2Tx 4Rx ULA Low	Type A 64QAM MCS 19	2	TDL-A 30ns, 10Hz
6	10MHz/15kHz	4Tx 4Rx ULA Low	Type A 16QAM MCS 13	3	TDL-A 30ns, 10Hz
7	10MHz/15kHz	4Tx 4Rx ULA Low	Type A 16QAM MCS 13	4	TDL-A 30ns, 10Hz
8	10MHz/15kHz	2Tx 2Rx ULA Med	Type A 16QAM MCS 13	2	TDL-A 30ns, 10Hz
9	10MHz/15kHz	4Tx 4RX ULA Med A	Type A 16QAM MCS 13	3	TDL-A 30ns, 10Hz
10	10MHz/15kHz	2Tx 2Rx ULA Low 2Tx 4Rx ULA Low	Type A 16QAM MCS 13	1	TDL-C 300ns, 100Hz
11	10MHz/15kHz	2Tx 2Rx ULA Low	Type B QPSK MCS 2	1	TDL-A 30ns, 10Hz
11	10MHz/15kHz	2Tx 2Rx ULA Low	Type B QPSK, MCS 2	1	TDL-A 30ns, 10Hz
12 (LTE-NR #1)	10MHz/15kHz	4Tx 2Rx ULA Low	Type A QPSK, MCS 4	1	TDL-A 30ns, 10Hz
13 (LTE-NR #2)	10MHz/15kHz	4Tx 2Rx ULA Low	Type A QPSK, MCS 4	1	TDL-A 30ns, 10Hz
14 (LTE-NR #3)	10MHz/15kHz	4Tx 2Rx ULA Low	Type B QPSK, MCS 4	1	TDL-A 30ns, 10Hz

Table 1 Evaluation cases considered in 3GPP for FR1 and FDD configuration.

The following 3GPP parameters and configurations are assumed:

- SSB/PBCH: Allocation in slot 0 in each second frame. 1 slot per 20 ms.
- CORESET configuration: Full BW allocation, 2 control symbols.
- PDSCH configuration:
  - Time domain: mapping type A (starting symbol 2, duration of 12 symbols).
  - Frequency domain: full bandwidth allocation.
- Scheduling in all slots but SSB/PBCH (19 out of every 20 subframes carry data).
- HARQ assumptions: RV sequence {0, 2, 3,1}, 4 HARQ processes.
- DMRS configuration of 2 DMRS symbols.

II PDSCH calibration results

Throughput results are obtained in this section and compared against the calibration results provided by specific companies in different 3GPP contributions [1-4].

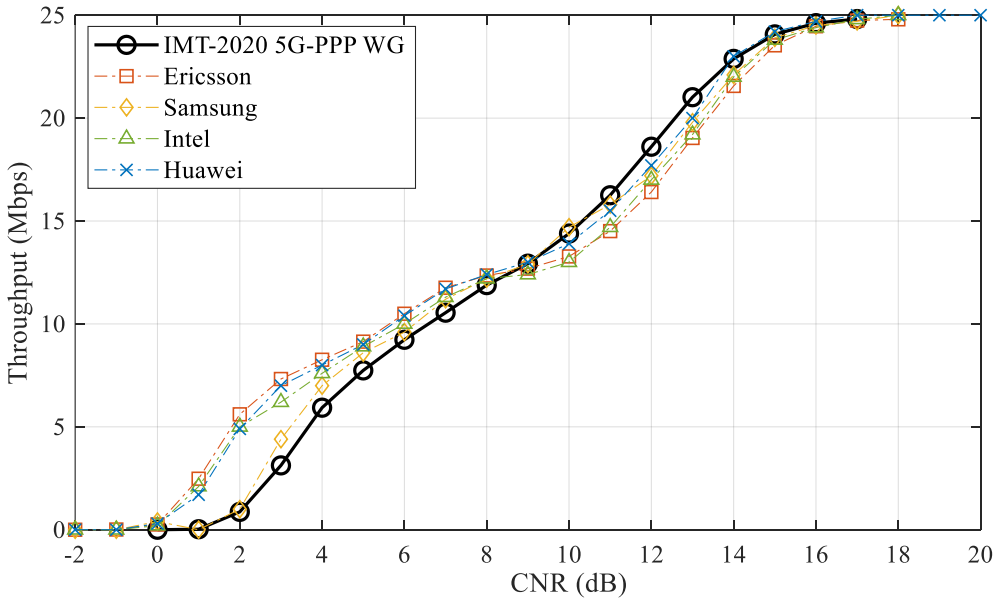

Figure 1 Throughput calibration results, case 4.

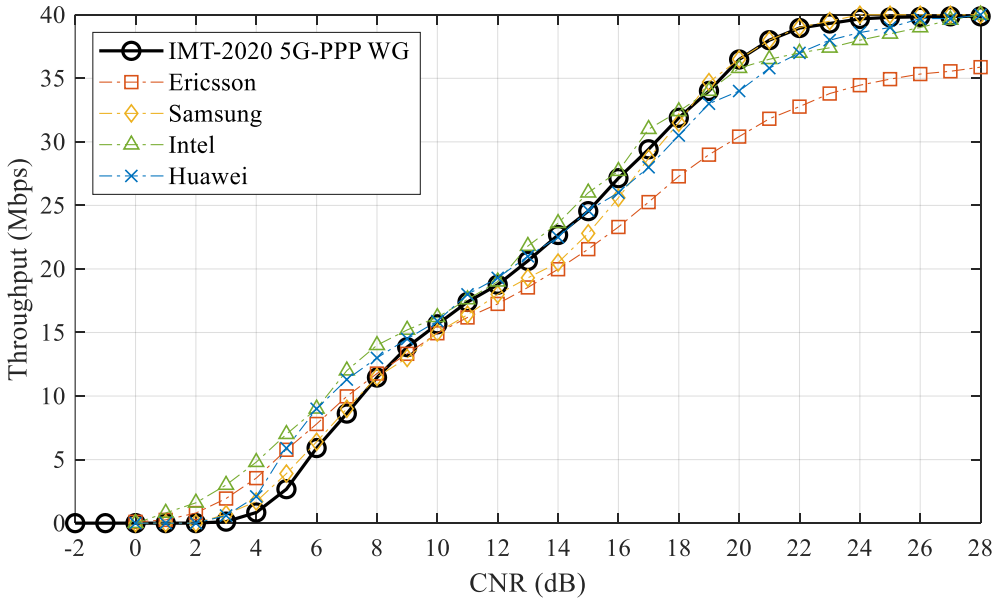

Figure 2 Throughput calibration results, case 5.

III PUSCH methodology and parameter configuration

The methodology in this case is aligned with the evaluation process followed in [5]. The 3GPP technical specifications TS 38.104 [6] and TS 38.141-1 [7] are used as a reference. 3GPP calibrated PUSCH results are obtained by different companies by measuring the SNR at the 70% of the maximum throughput. 3GPP defines different simulation cases with multiple antenna configurations, MCS, channel models, etc.

The selected parameter configuration for this calibration is:

- CP-OFDM without precoding and normal cyclic prefix.
- DMRS configuration: 1+1
- Minimum mean-squared error (MMSE) equalizer.
- Ideal estimation conditions.
- Channel models simulated with different sub-carrier spacing (SCS), MCS and bandwidth combinations, as shown in Table 2Table 1:

Evaluation case	Bandwidth (MHz)	SCS (kHz)	Antenna Configuration	Channel model	Delay spread (ns)	MCS
1	10	15	SIMO 1x2	TDL-B	100-400	2
2				TDL-C	300-100	16
3				TDL-A	30-10	20
4			MIMO 2x2	TDL-B	100-400	2
5				TDL-C	300-100	16
6	40	30	SIMO 1x2	TDL-B	100-400	2
7				TDL-C	300-100	16
8				TDL-A	30-10	20
9			MIMO 2x2	TDL-B	100-400	2

Table 2 Evaluation cases considered in 3GPP for FR1 and FDD configuration.

II PUSCH calibration results

Throughput results are obtained for the 9 selected evaluation cases and compared against the calibration results provided by specific companies. Figure 3 depicts an example of the calibration results for the evaluation case 1.

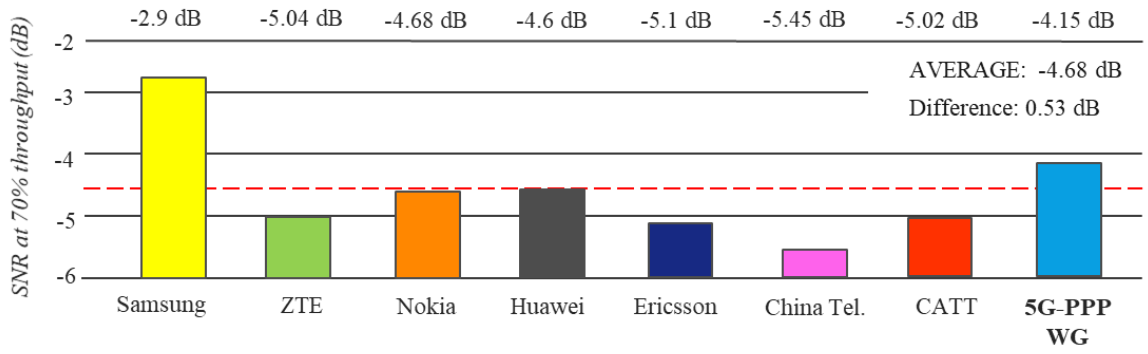

Figure 3 Example of calibration PUSCH results, case 1.

Table 3 shows all results provided by the companies as well as those obtained in this report. The difference between the average of them and these results is additionally shown.

	Evaluation case								
Company	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Samsung	-2.9	8.53	10.89	1.01	16.6	-3.99	8.5	10.37	-0.35
ZTE	-5.04	9.19	11.43	-1.16	17.24	-3.92	9.54	10.51	-0.94
CMCC	X	X	X	X	X	-4.6	6.8	10	X
Nokia	-4.68	7.81	9.77	-0.09	16.94	-4.84	7.62	9.54	-1.04
Huawei	-4.6	8.2	10.5	-1.24	15.94	-4.7	7.9	10.5	-1.23
Ericsson	-5.1	8.1	9.6	-0.9	15.8	-5	7.9	9.5	-1.1
China Telecom	-5.45	7.97	11.62	X	X	-5.4	7.9	10.43	X
CATT	-5.02	7.89	9.53	-1.13	15.31	-4.72	7.62	10.07	-1.08
Average	-4.68	8.24	10.48	-0.59	16.31	-4.68	7.97	10.12	-0.96
5G-PPP WG	-4.15	8.6	10.2	-0.45	15.45	-4.15	8.4	9.7	-0.1
Difference	0.53	0.36	0.28	0.14	0.86	0.53	0.43	0.41	0.86

Table 3 SNR (dB) at 70% of throughput. Evaluation cases 1 to 9.

References

[1] 3GPP R4-1812164, “Normal PDSCH demodulation alignment simulation results,” Intel Coorporation, October 2018.

[2] 3GPP R4-1812461, “Simulation results for NR UE PDSCH in FR1,” Samsung, October 2018.

[3] 3GPP R4-1813632, “Simulation results for NR PDSCH demodulation performance requirements,” Huawei, HiSilicon, October 2018.

[4] 3GPP R4-1813439, “Simulation results for NR UE PDSCH demodulation tests,” Ericsson, October 2018 .

[5] 3GPP R4-1905988, “Summary of ideal and impairment results for NR BS demodulation requirements - Update with results for pucch FR2 F3 with additional DMRS,” Ericsson, May 2019.

[6] 3GPP TS 38.104, V15.7.0, “Base Station (BS) radio transmission and reception”, September 2019.

[7] 3GPP TS 38.141-1, V15.3.0, “Base Station (BS) conformance testing Part 1: Conducted conformance testing”, September 2019.