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**3rd Generation Partnership Project;
Technical Specification Group Radio Access Network;**

Study on interference cancellation receiver for LTE BS (Release 15)

Approved by

WTSC

Wireless Technologies and Systems Committee



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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:

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- x the first digit:
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 - 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.

Introduction

With the wider usage of mobile applications like cloud services, social networking and point to point video/file sharing, uplink traffic load is becoming much heavier, and LTE uplink throughput improvement tends to be an essential and practical requirement for operators.

LTE uplink is interference limited in typical networks, and co-channel interference has substantial impact on uplink cell average and cell edge throughput. Base station (BS) MMSE-IRC receiver can bring in significant SINR gain over MMSE receiver by suppressing the inter-cell interference, in both homogeneous and heterogeneous networks, as concluded in TR 36.884 [2]. The RAN4 demodulation performance requirements for BS MMSE-IRC receiver are completed at RAN #72 meeting in June 2016 [3] [4].

Further evolution of BS receiver, such as interference cancellation (IC) receiver, can be considered to mitigate the intra-cell inter-user interference. In the intra-cell inter-user interference scenario where multiple users are co-scheduled on the same resource elements, BS IC receiver is expected to achieve noticeable throughput gain for cell centre and cell edge users.

Note that the utilization of BS IC receiver is transparent to the users, and the performance gain of BS IC receiver can also be enjoyed by legacy users.

To study the performance benefits of BS IC receiver, a new study item "Study on interference cancellation receiver for LTE BS" was approved at RAN #73 [5], and the current document summarizes the study done under this study item.

1 Scope

The study item should fulfil the following objectives:

- Identify the target deployment scenarios and the co-channel intra-cell interference conditions. The following scenario is to be considered:
- Intra-cell inter-user interference scenario where multiple users are co-scheduled on the same resource elements.
- Identify the reference receiver structures for PUSCH
- Receiver structures based on interference cancellation is considered as a starting point, and practical and realizable implementation should be taken into account.
- Agree on the interference models, interference levels and simulation parameters for link level evaluations
- Evaluate the link-level gain for PUSCH over baseline receiver
- Evaluate the link-level gain over baseline Rel-8 MMSE receiver for intra-cell inter-user interference scenarios.
- The prioritization of number of Rx antennas will be discussed and decided in study phase.

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 36.884: "Performance requirements of MMSE-IRC receiver for LTE BS".
- [3] 3GPP TSG RAN RP-150206: "Revised WID: Performance requirements of MMSE-IRC receiver for LTE BS".
- [4] 3GPP TSG RAN RP-160767: "Status report for WI: Performance requirements of MMSE-IRC receiver for LTE BS".
- [5] 3GPP TSG RAN RP-161485: "New SI: Study on interference cancellation receiver for LTE BS".
- [6] 3GPP TSG RAN4 R4-1704557: "Updated summary of BS IC simulation results without time and frequency offset".
- [7] 3GPP TSG RAN4 R4-1704558: "Updated summary of BS IC simulation results with time and frequency offset".

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions given in 3GPP 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 3GPP TR 21.905 [1].

3.2 Symbols

Void

3.3 Abbreviations

For the purposes of the present document, the abbreviations given in 3GPP 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 3GPP TR 21.905 [1].

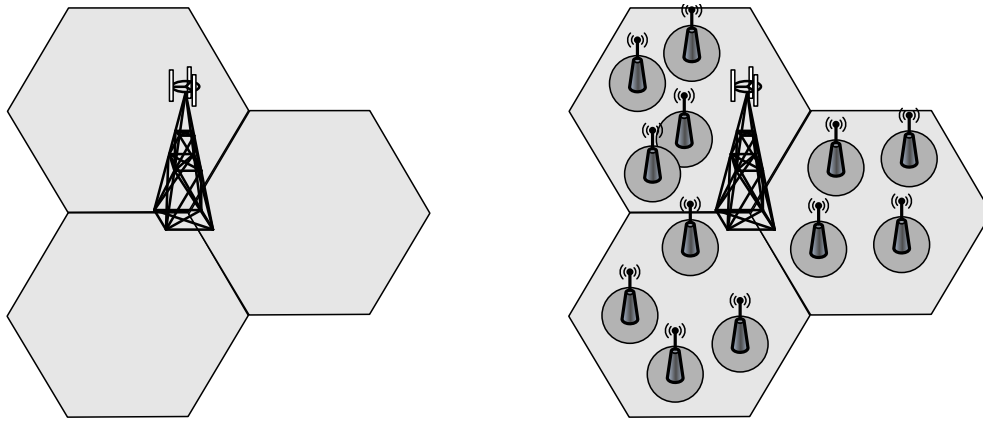
BS	Base Station
CW-IC	Code Word Level Interference Cancellation
DIP	Dominant Interferer Proportion
DM-RS	Demodulation Reference Signal
FO	Frequency offset
IC	Interference Cancellation
MCS	Modulation and Coding Scheme
MMSE-IRC	Minimum Mean Square Error - Interference Rejection Combining
PRB	Physical Resource Block
PUSCH	Physical Uplink Shared Channel
RB	Resource Block
RNTI	Radio Network Temporary Identity
RV	Redundancy Version
SINR	Signal to Interference and Noise Ratio
SNR	Signal to Noise Ratio
TO	Time Offset
TTI	Transmission Time Interval
UE	User Equipment

4 Scenarios and targeted/interference channels

4.1 Deployment scenarios

To estimate the link gain that intra-cell inter-user interference cancellation (IC) receiver of LTE/LTE-A BS can provide, the following two scenarios are considered for evaluation. The two scenarios as shown in Figure 4.1-1 are similar to those in [2] for BS MMSE-IRC receiver.

- **Scenario 1:** Homogeneous deployment with macro cell only
- **Scenario 2:** Heterogeneous deployment with co-channel low power node (LPN) within the macro cell coverage



(a) BS IC Scenario 1: Homogeneous network (b) BS IC Scenario 2: Heterogeneous network
Figure 4.1-1: LTE BS IC Scenarios

For the target cell in the above deployment scenarios, assume that K UEs are co-scheduled on the same time and frequency resource, as illustrated in Figure 4.1-2. BS IC receiver can be utilized to cancel the co-channel intra-cell interference among the K UEs.

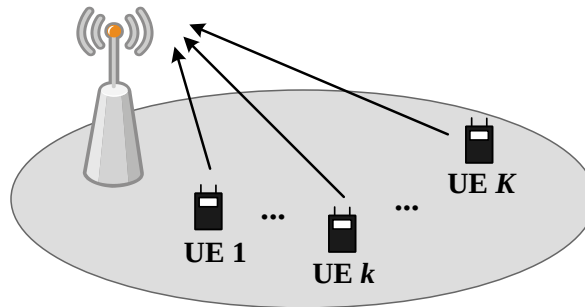


Figure 4.1-2: Illustration of K intra-cell co-scheduled UEs

4.2 Targeted and interference channels

On the evaluation of BS IC receiver for PUSCH, it was agreed that:

- The evaluation focuses on PUSCH to PUSCH collision.
- For both target PUSCH and interference PUSCH, 1Tx UE scenario is prioritized and 2Tx UE scenario is not covered.

5 Receiver structure

In the present document, the baseline and reference receiver structures for PUSCH are assumed as follows:

- MMSE-IRC receiver is used as the baseline receiver.
- Code word level IC (CW-IC) receiver is used for intra-cell inter-user interference mitigation in the reference receiver.
- At the target BS, full knowledge of the intra-cell inter-user interference parameters is available, including interfering PUSCH allocation, MCS level, HARQ redundancy version, RNTI, DM-RS configuration, etc.
- IC iteration may or may not be performed.

- In multi-cell scenario, for both baseline and reference receivers, implement inter-cell interference and noise whitening, i.e., inter-cell interference suppression with MMSE-IRC with the following assumptions as defined in TR 36.884 [2]:
 - DM-RS symbols are used to estimate the inter-cell interference covariance matrix.
 - The estimation of interference covariance matrix is performed at per PRB and per TTI basis.

6 Link performance characterization

6.1 Parameters for link level evaluation

6.1.1 Inter-cell interference modeling

As stated in clause 4.1 and clause 5, multi-cell scenario with homogeneous and co-channel heterogeneous deployments are considered for the evaluation, and inter-cell interference suppression with MMSE-IRC is implemented for both baseline and reference receivers. Thus explicit inter-cell interference is to be modelled in the link level evaluation.

The inter-cell interference model for the link level evaluation is given as below:

- Reuse DIP based interference statistical measurement defined in TR 36.884 [2], with some additional clarifications:
 - Intra-cell inter-user interference is not included in the DIP definition, and the DIP ratio is the ratio of the power of a given dominant inter-cell interferer over the total power of all inter-cell interferers along with the white noise.
 - The DIP ratio is exactly same for the multiple intra-cell UEs.
- Model 1 inter-cell interferer (i.e., the strongest interferer), which is time-synchronous with the desired signal.
- To make trade-off between the coverage and workload of the evaluation, introduce two sets of inter-cell interference profiles:
 - Set 1: High interference level in co-channel heterogeneous scenario
 - Take the DIP1 value at 85%-tile of the unconditional DIP1 distribution in heterogeneous scenario
 - Based on the average of interested companies' results in Table 6.3.2.2-1 or Table 6.4-2 of TR 36.884 [2], DIP1 = -0.43 dB
 - Set 2: Low interference level in homogeneous scenario
 - Take the DIP1 value at 15%-tile of the unconditional DIP1 distribution in homogeneous scenario
 - Based on the average of interested companies' results in Table 6.3.1.2-1 of TR 36.884 [2], DIP1 = -5.45 dB

6.1.2 Link level evaluation parameters

The common parameters for link level evaluation are given in Table 6.1.2-1. The evaluation cases with specific parameters are given in Table 6.1.2-2 and Table 6.1.2-3. The performance with both baseline receiver and reference receiver are provided for comparison purpose.

Below are some explanations on the evaluation parameters:

- *BS Rx antenna number*: the evaluation focuses on 2 Rx and 4 Rx BS. 8 Rx BS is not covered in the evaluation due to two reasons: on one hand, 8 Rx IC gain is relatively limited for up to 4 co-scheduled intra-cell UEs; on the other hand, a large number of channel faders are needed for potential 8 Rx IC test.

- *Number of co-scheduled intra-cell UEs:* 2 and 4 co-scheduled intra-cell UEs are modeled for 2 Rx and 4 Rx BS respectively. 4 intra-cell UEs are modeled for 4 Rx BS due to two reasons: on one hand, IC gain for 2 intra-cell UEs is not as meaningful as for 4 intra-cell UEs; on the other hand, if the BS can properly implement the channel estimation and IC for 4 intra-cell UEs, it can also do that for less than 4 intra-cell UEs in practical.
- *SNR distribution for the co-scheduled intra-cell UEs:* as known, the PUSCH transmission power is a function of the coupling loss, and the uplink received SNR difference for any two intra-cell UEs is observed as relatively small. Thus, considering the intra-cell UEs' SNR distribution, two cases are evaluated, including: a) equal average SNR, where the short-term variation remains, and b) unequal average SNR with a maximal 3dB SNR difference among UEs.
- *Spatial correlation level for the intra-cell UEs:* low correlation among the intra-cell UEs is modeled, i.e., independent fast fading for the intra-cell UEs.
- *DMRS configuration:* the same base sequence and different phase rotations/cyclic shifts are assigned for co-scheduled intra-cell UEs, and different base sequences are assigned for UEs associated with different cells.
- *Performance output:* Interested companies are invited to provide the throughput versus SINR curves for each individual intra-cell UE for the baseline and reference receivers. The SINR at 85% maximum throughput is taken as the performance measurement point.
- Note that SINR represents one intra-cell UE's signal to inter-cell interference and noise ratio, i.e., the signal power is the power of one intra-cell UE, and intra-cell inter-user interference is not included in the interference part when calculating SINR.

Table 6.1.2-1: Common parameters of link level evaluation

Parameters		Values
Channel bandwidth		10 MHz
PRB allocation		Full PRB allocation, i.e., 50 PRBs, for all the intra-cell and inter-cell UEs involved in the evaluation
Cyclic prefix		Normal
Inter-cell interference modelling	Number of explicitly modelled interferers	1
	Interference modulation	16 QAM
	DIP	Set 1: High interference level in co-channel heterogeneous scenario, DIP1= -0.43 dB Set 2: Low interference level in homogeneous scenario, DIP1 = -5.45 dB
UE Tx antenna number		1
BS Rx antenna number		2, 4
Number of co-scheduled intra-cell UEs		2 intra-cell UEs for 2 Rx BS 4 intra-cell UEs for 4 Rx BS
SNR distribution for the co-scheduled intra-cell UEs		Case 1: Equal average SNR (short-term variation remains) Case 2: Unequal average SNR - For 2 intra-cell UEs: the SNR of UE1 is 3 dB lower than that of UE2. - For 4 intra-cell UEs: the SNR of UE1 and UE3 is the same, the SNR of UE2 and UE4 is the same, the SNR of UE1 & UE3 is 3 dB lower than that of UE2 & UE4.
Propagation condition (intra-cell UEs, inter-cell UEs)		(EPA5 low, ETU5 low), (EVA70 low, ETU70 low)
AWGN power level for 10MHz channel bandwidth		-83.5 dBm / 9MHz
Time offset and frequency offset	Intra-cell UEs	Case 1: Zero time and frequency offset Case 2: Non-zero time and frequency offset Time offset: 2 intra-cell UEs: [-1, 1] us for [UE1, UE2] 4 intra-cell UEs: [-1, -0.5, 0.5, 1] us for [UE1, UE2, UE3, UE4] Frequency offset: 2 intra-cell UEs: [-200, 200] Hz for [UE1, UE2] 4 intra-cell UEs: [-200, -100, 100, 200] Hz for [UE1, UE2, UE3, UE4]
	Inter-cell UEs	Zero time and frequency offset
DM-RS sequence for the intra-cell and inter-cell UEs		- The cell id for the intra-cell UEs is 0, and the cell id for inter-cell interfering UE is 1. - Group hopping and sequence hopping are disabled, and $\Delta_{ss} = 0$ for all the simulated PUSCHs. $n_{\text{DMRS}}^{(1)} = [0, 6]$ for 2 intra-cell UEs, $n_{\text{DMRS}}^{(1)} = [0, 3, 6, 9]$ for 4 intra-cell UEs; and $n_{\text{DMRS},0}^{(2)} = 0$.
Frequency hopping, TTI bundling		Disabled
Maximal number of HARQ transmissions		4
HARQ RV sequence		0, 2, 3, 1

Table 6.1.2-2: Cases for equal average SNR

Case No.	Rx antenna	No. of UEs	Propagation condition (intra-cell UEs, inter-cell UEs)	MCS level (intra-cell UEs)	Inter-cell interference scenario
E1-a1	2 Rx	2 UEs	(EPA5 low, ETU5 low)	MCS 10	DIP1= -0.43 dB
E1-a2				MCS 15	
E1-b1			(EVA70 low, ETU70 low)	MCS 15	DIP1 = -5.45 dB
E1-b2				MCS 10	
E1-c			(EPA5 low, ETU5 low)	MCS 21	DIP1= -0.43 dB
E2-a1	4 Rx	4 UEs	(EPA5 low, ETU5 low)	MCS 10	DIP1= -0.43 dB
E2-a2				MCS 15	
E2-b1			(EVA70 low, ETU70 low)	MCS 15	DIP1 = -5.45 dB
E2-b2				MCS 10	

Table 6.1.2-3: Cases for unequal average SNR

Case No.	Rx antenna	No. of UEs	Propagation condition (intra-cell UEs, inter-cell UEs)	MCS level (intra-cell UEs)	Inter-cell interference scenario
U1-a1	2 Rx	2 UEs	(EPA5 low, ETU5 low)	MCS 10	DIP1= -0.43 dB
U1-a2				MCS 15	
U1-b1			(EVA70 low, ETU70 low)	MCS 15	DIP1 = -5.45 dB
U1-b2				MCS 10	
U1-c			(EPA5 low, ETU5 low)	MCS 21	DIP1= -0.43 dB
U1-d			(EPA5 low, ETU5 low)	MCS 10 for UE1 MCS 15 for UE2	DIP1= -0.43 dB
U1-e			(EPA5 low, ETU5 low)	MCS 15 for UE1 MCS 10 for UE2	DIP1= -0.43 dB
U2-a1	4 Rx	4 UEs	(EPA5 low, ETU5 low)	MCS 10	DIP1= -0.43 dB
U2-a2				MCS 15	
U2-b1			(EVA70 low, ETU70 low)	MCS 15	DIP1 = -5.45 dB
U2-b2				MCS 10	
U2-c			(EPA5 low, ETU5 low)	MCS 10 for UE1, 3 MCS 15 for UE2, 4	DIP1= -0.43 dB
U2-d			(EPA5 low, ETU5 low)	MCS 15 for UE1, 3 MCS 10 for UE2, 4	DIP1= -0.43 dB

6.2 Link level simulation results

6.2.1 Link level simulation results without time and frequency offset

The document R4-1704557 [6] captures the link level simulation results without time and frequency offset from companies.

Table 6.2.1-1 to Table 6.2.1-4 compare the simulation results between baseline receiver and IC receiver for equal average SNR with 2Rx, equal average SNR with 4Rx, unequal average SNR with 2Rx, and unequal average SNR with 4Rx respectively. Table 6.2.1-5 summarizes averaged IC gain over baseline receiver.

Table 6.2.1-1: Summary of simulation results for equal average SNR, 2Rx, required SINR at 85% TP

Case Num	UE id	China Telecom			ZTE		
		Baseline receiver (dB)	IC receiver (dB)	SINR gain (dB)	Baseline receiver (dB)	IC receiver (dB)	SINR gain (dB)
E1-a1	UE1	4.92	1.59	3.33	5.73	1.67	4.06
	UE2	4.78	1.66	3.12	5.45	1.77	3.68
E1-a2	UE1	11.19	8.30	2.89	11.72	8.05	3.67
	UE2	11.44	8.32	3.12	11.79	8.10	3.69
E1-b1	UE1	12.77	10.96	1.81	13.09	11.43	1.66
	UE2	12.87	10.94	1.93	13.41	11.40	2.01
E1-b2	UE1	6.71	4.90	1.81	7.02	5.01	2.01
	UE2	6.77	4.89	1.88	6.97	5.03	1.94
E1-c	UE1	18.09	14.69	3.40	18.02	14.73	3.29
	UE2	17.83	14.71	3.12	18.15	15.02	3.13

Case Num	UE id	Nokia, Alcatel-Lucent Shanghai Bell			Huawei		
		Baseline receiver (dB)	IC receiver (dB)	SINR gain (dB)	Baseline receiver (dB)	IC receiver (dB)	SINR gain (dB)
E1-a1	UE1	5.48	2.49	2.98	3.4	1.2	2.2
	UE2	5.77	2.55	3.21	3.6	1.3	2.3
E1-a2	UE1	11.73	9.15	2.58	9.8	8.1	1.7
	UE2	11.96	9.13	2.83	10.2	8.1	2.1
E1-b1	UE1	12.46	11.03	1.44	11.6	10.14	1.46
	UE2	12.56	11.04	1.52	11.6	10.0	1.6
E1-b2	UE1	6.60	5.16	1.44	5.9	4.76	1.14
	UE2	6.71	5.20	1.51	5.91	4.71	1.20
E1-c	UE1	18.84	16.09	2.75	16.20	14.46	1.74
	UE2	18.94	16.07	2.87	16.50	14.30	2.20

Table 6.2.1-2: Summary of simulation results for equal average SNR, 4Rx, required SINR at 85% TP

Case Num	UE id	China Telecom			ZTE		
		Baseline receiver (dB)	IC receiver (dB)	SINR gain (dB)	Baseline receiver (dB)	IC receiver (dB)	SINR gain (dB)
E2-a1	UE1	-0.10	-3.67	3.57	-0.91	-4.31	3.40
	UE2	0.44	-3.71	4.15	-0.43	-4.34	3.91
	UE3	0.25	-3.72	3.97	-0.25	-4.34	4.09
	UE4	0.01	-3.66	3.67	-0.83	-4.30	3.47
E2-a2	UE1	9.25	3.71	5.54	9.63	4.02	5.61
	UE2	8.79	3.71	5.08	9.44	3.96	5.48
	UE3	9.08	3.75	5.33	9.45	3.95	5.50
	UE4	9.08	3.74	5.34	9.44	3.96	5.48
E2-b1	UE1	11.55	8.57	2.98	12.06	9.00	3.06
	UE2	11.58	8.56	3.02	11.99	9.00	2.99
	UE3	11.62	8.56	3.06	12.18	8.98	3.20
	UE4	11.59	8.56	3.03	12.00	8.99	3.01
E2-b2	UE1	4.66	2.29	2.37	4.73	2.02	2.71
	UE2	4.73	2.29	2.44	4.66	2.06	2.60
	UE3	4.75	2.28	2.47	4.69	2.04	2.65
	UE4	4.74	2.26	2.48	4.68	2.04	2.64

Case Num	UE id	Nokia, Alcatel-Lucent Shanghai Bell			Huawei		
		Baseline receiver (dB)	IC receiver (dB)	SINR gain (dB)	Baseline receiver (dB)	IC receiver (dB)	SINR gain (dB)
E2-a1	UE1	1.66	-3.07	4.73	-1.00	-3.93	2.93
	UE2	2.64	-2.92	5.56	-0.72	-3.79	3.07
	UE3	1.31	-3.16	4.47	-0.07	-3.61	3.54
	UE4	1.48	-3.14	4.61	-0.69	-3.93	3.24
E2-a2	UE1	11.57	5.06	6.51	7.15	3.75	3.40
	UE2	12.02	5.15	6.87	7.00	3.84	3.16

E2-b1	UE3	11.17	5.03	6.14	7.70	4.00	3.70
	UE4	11.04	5.02	6.02	7.00	3.59	3.41
	UE1	11.46	8.65	2.80	10.00	7.82	2.18
	UE2	11.47	8.69	2.78	9.84	7.75	2.09
	UE3	11.49	8.66	2.82	9.82	7.75	2.07
E2-b2	UE4	11.41	8.62	2.79	9.90	7.51	2.39
	UE1	4.55	2.02	2.53	3.45	1.79	1.66
	UE2	4.57	2.06	2.51	3.31	1.63	1.68
	UE3	4.60	2.09	2.50	3.34	1.69	1.65
	UE4	4.49	1.99	2.50	3.38	1.50	1.88

Table 6.2.1-3: Summary of simulation results for unequal average SNR, 2Rx, required SINR at 85% TP

Case Num	UE id	China Telecom			ZTE		
		Baseline receiver (dB)	IC receiver (dB)	SINR gain (dB)	Baseline receiver (dB)	IC receiver (dB)	SINR gain (dB)
U1-a1	UE1	5.59	0.25	5.34	6.60	0.15	6.45
	UE2	0.31	-1.19	1.5	1.85	-1.35	3.20
U1-a2	UE1	12.01	6.80	5.21	12.25	6.15	6.10
	UE2	7.52	6.17	1.35	7.70	5.10	2.60
U1-b1	UE1	13.38	9.32	4.06	14.01	10.01	4.00
	UE2	9.06	8.53	0.53	9.76	9.00	0.76
U1-b2	UE1	7.46	3.95	3.51	8.00	3.95	4.05
	UE2	2.87	2.25	0.62	3.34	2.98	0.36
U1-c	UE1	18.39	13.34	5.05	18.78	12.95	5.83
	UE2	14.17	12.91	1.26	14.61	12.24	2.37
U1-d	UE1	5.56	3.13	2.43	6.61	4.05	2.56
	UE2	7.34	3.46	3.88	8.01	3.99	4.02
U1-e	UE1	12.30	4.14	8.16	12.20	4.60	7.60
	UE2	0.21	-0.57	0.78	0.92	0.85	0.07
Case Num	UE id	Nokia, Alcatel-Lucent Shanghai Bell			Huawei		
		Baseline receiver (dB)	IC receiver (dB)	SINR gain (dB)	Baseline receiver (dB)	IC receiver (dB)	SINR gain (dB)
U1-a1	UE1	6.75	1.53	5.22	4.77	0.77	4.0
	UE2	1.07	0.08	0.99	-0.3	-2.00	1.70
U1-a2	UE1	12.63	7.66	4.98	10.54	6.51	4.03
	UE2	7.78	7.01	0.76	6.24	5.50	0.74
U1-b1	UE1	13.26	9.50	3.76	12.28	8.62	3.66
	UE2	8.60	8.67	-0.07	7.85	7.70	0.15
U1-b2	UE1	7.41	4.31	3.1	6.75	3.70	3.05
	UE2	2.73	2.49	0.24	2.02	1.60	0.42
U1-c	UE1	19.31	14.46	4.85	16.70	12.74	3.96
	UE2	15.26	14.03	1.23	13.00	12.00	1.00
U1-d	UE1	6.75	4.07	2.68	4.80	3.35	1.45
	UE2	7.77	4.40	3.36	6.10	3.66	2.44
U1-e	UE1	12.63	5.32	7.30	10.54	4.50	6.04
	UE2	1.08	1.18	-0.10	-0.42	-0.80	0.38

Table 6.2.1-4: Summary of simulation results for unequal average SNR, 4Rx, required SINR at 85% TP

Case Num	UE id	China Telecom			ZTE		
		Baseline receiver (dB)	IC receiver (dB)	SINR gain (dB)	Baseline receiver (dB)	IC receiver (dB)	SINR gain (dB)
U2-a1	UE1	2.15	-4.54	6.69	0.50	-4.87	5.37
	UE2	-4.89	-6.92	2.03	-4.00	-6.68	2.68
	UE3	2.16	-4.57	6.73	0.50	-4.87	5.37
	UE4	-4.92	-6.86	1.94	-4.00	-6.66	2.66
U2-a2	UE1	10.25	2.29	7.96	8.40	0.35	8.05
	UE2	4.43	0.71	3.72	2.95	-0.69	3.64
	UE3	10.18	2.34	7.84	8.35	0.32	8.03
	UE4	3.98	0.63	3.35	2.40	-0.73	3.13
U2-b1	UE1	12.40	6.97	5.43	13.10	7.30	5.80
	UE2	7.45	5.14	2.31	8.20	5.94	2.26

	UE3	12.54	6.97	5.57	13.10	7.30	5.80
	UE4	7.44	5.15	2.29	8.20	5.97	2.23
U2-b2	UE1	5.79	1.45	4.34	6.43	2.07	4.36
	UE2	0.59	-1.12	1.71	1.20	-0.45	1.65
	UE3	5.83	1.46	4.37	6.48	2.09	4.39
	UE4	0.57	-1.13	1.70	1.21	-0.44	1.65
U2-c	UE1	2.14	-2.16	4.30	2.24	-2.15	4.39
	UE2	4.33	-1.42	5.75	4.42	-0.63	5.05
	UE3	2.07	-2.14	4.21	2.24	-2.15	4.39
	UE4	4.29	-1.35	5.64	4.41	-0.63	5.04
U2-d	UE1	10.28	-0.44	10.72	10.45	-0.37	10.82
	UE2	-4.54	-6.95	2.41	-4.00	-6.78	2.78
	UE3	10.23	-0.50	10.73	10.35	-0.37	10.72
	UE4	-4.53	-6.88	2.35	-4.00	-6.78	2.78
Case Num	UE id	Nokia, Alcatel-Lucent Shanghai Bell			Huawei		
		Baseline receiver (dB)	IC receiver (dB)	SINR gain (dB)	Baseline receiver (dB)	IC receiver (dB)	SINR gain (dB)
U2-a1	UE1	4.53	-3.92	8.45	0.59	-4.83	5.42
	UE2	-3.76	-6.10	2.33	-4.60	-6.60	2.00
	UE3	4.08	-3.96	8.04	1.70	-4.60	6.30
	UE4	-4.48	-6.34	1.87	-4.60	-6.66	2.06
U2-a2	UE1	12.87	3.71	9.16	8.28	1.96	6.32
	UE2	6.83	1.93	4.90	2.11	0.85	1.26
	UE3	12.49	3.62	8.87	8.87	2.27	6.60
	UE4	5.60	1.76	3.84	2.28	0.55	1.73
U2-b1	UE1	12.65	7.16	5.49	11.00	6.40	4.60
	UE2	7.05	5.26	1.79	5.70	5.00	0.70
	UE3	12.69	7.18	5.51	11.0	6.40	4.60
	UE4	6.96	5.26	1.70	5.7	4.8	0.90
U2-b2	UE1	5.71	1.44	4.27	4.52	1.26	3.26
	UE2	0.11	-1.02	1.13	0.10	-1.15	1.25
	UE3	5.73	1.46	4.27	4.40	1.22	3.18
	UE4	0.02	-1.04	1.06	-0.10	-1.10	1.00
U2-c	UE1	4.52	-1.21	5.73	0.6	-1.80	2.40
	UE2	6.82	-0.50	7.32	1.8	-0.90	2.70
	UE3	4.09	-1.26	5.35	1.8	-1.40	3.20
	UE4	5.63	-0.65	6.27	2.0	-1.50	3.50
U2-d	UE1	12.86	0.72	12.14	10.00	0.04	9.96
	UE2	-3.75	-6.09	2.35	-5.80	-6.30	0.50
	UE3	12.49	0.65	11.84	9.80	0.36	9.44
	UE4	-4.48	-6.37	1.90	-5.70	-6.30	0.60

Table 6.2.1-5: Companies' averaged performance gain of IC over baseline receiver, required SINR at 85% TP

	Case Num	Average SINR gain (dB)			
		UE1	UE2	UE3	UE4
Equal SNR	E1-a1	3.1	3.1		
	E1-a2	2.7	2.9		
	E1-b1	1.6	1.8		
	E1-b2	1.6	1.6		
	E1-c	2.8	2.8		
	E2-a1	3.7	4.2	4.0	3.7
	E2-a2	5.3	5.1	5.2	5.1
	E2-b1	2.8	2.7	2.8	2.8
	E2-b2	2.3	2.3	2.3	2.4
Unequal SNR	U1-a1	5.3	1.8		
	U1-a2	5.1	1.4		
	U1-b1	3.9	0.3		
	U1-b2	3.4	0.4		
	U1-c	4.9	1.5		
	U1-d	2.3	3.4		
	U1-e	7.3	0.3		
	U2-a1	6.5	2.3	6.6	2.1
	U2-a2	7.9	3.4	7.8	3.0
	U2-b1	5.3	1.8	5.4	1.8
	U2-b2	4.1	1.4	4.1	1.4
	U2-c	4.2	5.2	4.3	5.1
	U2-d	10.9	2.0	10.7	1.9

6.2.2 Link level simulation results with time and frequency offset

The document R4-1704558 [7] captures the link level simulation results with time and frequency offset from companies.

Table 6.2.2-1 to Table 6.2.2-4 compare the simulation results between baseline receiver and IC receiver for equal average SNR with 2Rx, equal average SNR with 4Rx, unequal average SNR with 2Rx, and unequal average SNR with 4Rx respectively. Table 6.2.2-5 summarizes averaged IC gain over baseline receiver.

In addition, one company provided simulation results on performance comparison between the following two cases. Simulations were conducted for Case E2-a1 and E2-b1 with equal average SNR. The results are shown in Table 6.2.2-6, and the observation is that there is 1-2dB loss when TO/FO is not handled.

- TO/FO modelled but not handled in receiver algorithm
- TO/FO modelled and handled in receiver algorithm

Table 6.2.2-1: Summary of simulation results for equal average SNR, 2Rx, required SINR at 85% TP

Case Num	UE id	China Telecom			Nokia, Alcatel-Lucent Shanghai Bell		
		Baseline receiver (dB)	IC receiver (dB)	SINR gain (dB)	Baseline receiver (dB)	IC receiver (dB)	SINR gain (dB)
E1-a1	UE1	4.66	1.64	3.02	5.58	2.68	2.90
	UE2	4.76	1.61	3.15	5.75	2.87	2.89
E1-a2	UE1	11.77	8.62	3.15	11.72	9.27	2.45
	UE2	11.57	8.60	2.97	11.83	9.39	2.44
E1-b1	UE1	13.06	11.25	1.81	12.39	11.06	1.33
	UE2	13.05	11.22	1.82	12.41	11.08	1.33
E1-b2	UE1	6.83	4.92	1.91	6.66	5.25	1.40
	UE2	6.76	4.96	1.80	6.71	5.25	1.46
E1-c	UE1	17.90	15.28	2.63	18.64	16.08	2.56
	UE2	18.40	15.32	3.08	18.57	16.19	2.39

Case Num	UE id	ZTE			Huawei		
		Baseline receiver (dB)	IC receiver (dB)	SINR gain (dB)	Baseline receiver (dB)	IC receiver (dB)	SINR gain (dB)
E1-a1	UE1	5.21	2.34	2.87	3.60	1.30	2.30
	UE2	5.67	2.12	3.55	3.80	1.50	2.30
E1-a2	UE1	12.24	9.13	3.11	9.90	8.10	1.80
	UE2	11.94	9.38	2.56	10.40	8.10	2.30
E1-b1	UE1	13.75	11.90	1.84	11.60	10.17	1.43
	UE2	13.77	11.93	1.84	11.60	10.10	1.50
E1-b2	UE1	7.60	5.83	1.77	6.00	4.80	1.20
	UE2	7.71	5.74	1.98	6.00	4.73	1.27
E1-c	UE1	19.03	15.91	3.12	16.30	14.50	1.80
	UE2	19.06	15.99	3.07	16.60	14.40	2.20

Table 6.2.2-2: Summary of simulation results for equal average SNR, 4Rx, required SINR at 85% TP

Case Num	UE id	China Telecom			Nokia, Alcatel-Lucent Shanghai Bell		
		Baseline receiver (dB)	IC receiver (dB)	SINR gain (dB)	Baseline receiver (dB)	IC receiver (dB)	SINR gain (dB)
E2-a1	UE1	0.29	-3.66	3.95	1.58	-2.77	4.36
	UE2	0.46	-3.79	4.25	2.37	-2.66	5.03
	UE3	0.38	-3.75	4.13	1.07	-2.94	4.01
	UE4	0.11	-3.82	3.93	1.25	-2.91	4.16
E2-a2	UE1	9.08	3.71	5.36	10.53	5.29	5.24
	UE2	9.10	3.74	5.36	10.67	5.40	5.27
	UE3	8.88	3.76	5.12	9.76	5.32	4.45
	UE4	9.25	3.75	5.50	9.76	5.26	4.50
E2-b1	UE1	11.79	8.68	3.11	11.10	8.51	2.59
	UE2	11.72	8.68	3.04	11.02	8.51	2.50
	UE3	11.68	8.67	3.01	11.02	8.55	2.46
	UE4	11.81	8.68	3.13	10.96	8.51	2.45
E2-b2	UE1	4.66	2.27	2.39	4.43	2.06	2.37
	UE2	4.71	2.30	2.40	4.40	2.10	2.30
	UE3	4.68	2.30	2.38	4.40	2.06	2.34
	UE4	4.75	2.32	2.43	4.33	2.01	2.33

Case Num	UE id	ZTE			Huawei		
		Baseline receiver (dB)	IC receiver (dB)	SINR gain (dB)	Baseline receiver (dB)	IC receiver (dB)	SINR gain (dB)
E2-a1	UE1	1.17	-2.76	3.93	-1.00	-3.90	2.9
	UE2	1.35	-2.94	4.29	-0.70	-3.75	3.05
	UE3	1.10	-3.01	4.11	-0.04	-3.58	3.54
	UE4	0.93	-3.08	4.01	-1.00	-3.90	2.9
E2-a2	UE1	9.94	4.53	5.41	6.90	3.81	3.09
	UE2	9.78	4.50	5.28	7.00	3.83	3.17
	UE3	9.69	4.48	5.21	7.80	4.10	3.7
	UE4	10.09	4.49	5.60	7.00	3.70	3.3
E2-b1	UE1	12.70	9.54	3.15	10.10	7.90	2.2
	UE2	12.63	9.38	3.25	9.85	7.00	2.85
	UE3	12.47	9.51	2.96	9.84	7.82	2.02
	UE4	12.51	9.43	3.08	9.92	7.10	2.82
E2-b2	UE1	5.36	3.15	2.21	3.47	1.77	1.7
	UE2	5.57	3.01	2.56	3.32	1.67	1.65
	UE3	5.57	3.09	2.49	3.37	1.72	1.65
	UE4	5.57	3.19	2.38	3.40	1.60	1.8

Table 6.2.2-3: Summary of simulation results for unequal average SNR, 2Rx, required SINR at 85% TP

Case Num	UE id	China Telecom			Nokia, Alcatel-Lucent Shanghai Bell		
		Baseline receiver (dB)	IC receiver (dB)	SINR gain (dB)	Baseline receiver (dB)	IC receiver (dB)	SINR gain (dB)
U1-a1	UE1	5.69	0.36	5.33	6.77	1.67	5.10
	UE2	-0.02	-0.98	0.96	1.07	0.24	0.84

U1-a2	UE1	12.42	7.23	5.19	12.53	7.80	4.73
	UE2	7.28	6.33	0.95	7.71	7.10	0.61
U1-b1	UE1	13.70	9.69	4.00	13.13	9.56	3.57
	UE2	9.25	8.70	0.55	8.57	8.66	-0.09
U1-b2	UE1	7.54	4.04	3.50	7.42	4.46	2.97
	UE2	2.91	2.21	0.70	2.74	2.48	0.27
U1-c	UE1	18.55	14.38	4.16	19.06	14.71	4.35
	UE2	14.37	13.20	1.17	14.98	14.00	0.99
U1-d	UE1	6.14	3.39	2.75	6.78	4.20	2.58
	UE2	7.41	3.87	3.54	7.71	4.75	2.96
U1-e	UE1	12.04	4.66	7.38	12.56	5.67	6.88
	UE2	0.49	0.02	0.47	1.07	1.15	-0.09
Case Num	UE id	ZTE			Huawei		
		Baseline receiver (dB)	IC receiver (dB)	SINR gain (dB)	Baseline receiver (dB)	IC receiver (dB)	SINR gain (dB)
U1-a1	UE1	6.40	0.98	5.42	4.80	0.76	4.04
	UE2	1.15	-0.40	1.55	-0.20	-1.90	1.70
U1-a2	UE1	13.03	7.50	5.53	10.60	6.54	4.06
	UE2	8.47	6.81	1.66	6.30	5.60	0.7
U1-b1	UE1	14.33	10.16	4.18	12.35	8.70	3.65
	UE2	9.97	9.40	0.57	7.90	7.70	0.2
U1-b2	UE1	8.19	4.85	3.34	6.80	3.70	3.1
	UE2	3.76	2.87	0.89	2.20	1.50	0.7
U1-c	UE1	19.35	14.31	5.04	16.80	12.74	4.06
	UE2	14.99	13.80	1.19	13.10	12.00	1.1
U1-d	UE1	6.51	4.13	2.37	4.80	3.40	1.4
	UE2	8.34	4.57	1.77	6.20	3.70	2.5
U1-e	UE1	13.2	4.96	8.24	10.54	4.60	5.94
	UE2	1.0	0.38	0.61	-0.40	-0.60	0.2

Table 6.2.2-4: Summary of simulation results for unequal average SNR, 4Rx, required SINR at 85% TP

Case Num	UE id	China Telecom			Nokia, Alcatel-Lucent Shanghai Bell		
		Baseline receiver (dB)	IC receiver (dB)	SINR gain (dB)	Baseline receiver (dB)	IC receiver (dB)	SINR gain (dB)
U2-a1	UE1	2.49	-4.57	7.06	4.02	-3.33	7.35
	UE2	-4.91	-6.80	1.89	-3.65	-5.98	2.33
	UE3	2.03	-4.61	6.64	3.50	-3.63	7.13
	UE4	-4.74	-6.91	2.16	-4.47	-6.25	1.78
U2-a2	UE1	10.45	2.48	7.97	11.51	4.06	7.45
	UE2	4.45	0.44	4.02	5.86	2.00	3.86
	UE3	10.47	2.45	8.02	10.90	3.87	7.03
	UE4	4.26	0.51	3.76	4.84	1.84	3.00
U2-b1	UE1	12.76	7.25	5.51	12.11	7.17	4.94
	UE2	7.50	5.29	2.22	6.59	5.14	1.45
	UE3	12.74	7.22	5.51	11.98	7.11	4.87
	UE4	7.62	5.27	2.35	6.53	5.14	1.39
U2-b2	UE1	5.80	1.49	4.32	5.50	1.49	4.01
	UE2	0.57	-1.10	1.68	0.00	-1.03	1.03
	UE3	5.72	1.52	4.20	5.48	1.45	4.03
	UE4	0.56	-1.09	1.65	-0.05	-1.09	1.04
U2-c	UE1	1.83	-2.07	3.90	4.03	-0.95	4.98
	UE2	4.39	-1.40	5.79	5.84	-0.28	6.12
	UE3	2.23	-2.19	4.41	3.51	-1.00	4.52
	UE4	4.58	-1.48	6.06	4.85	-0.40	5.25
U2-d	UE1	10.51	-0.16	10.68	11.51	1.53	9.98
	UE2	-4.67	-7.02	2.35	-3.65	-6.01	2.36
	UE3	10.03	-0.41	10.44	10.90	1.07	9.83
	UE4	-4.75	-6.95	2.20	-4.45	-6.30	1.85

Case Num	UE id	ZTE			Huawei		
		Baseline receiver (dB)	IC receiver (dB)	SINR gain (dB)	Baseline receiver (dB)	IC receiver (dB)	SINR gain (dB)
U2-a1	UE1	3.14	-3.93	7.07	0.60	-4.80	5.40
	UE2	-4.15	-6.10	1.96	-4.50	-6.60	2.1
	UE3	2.83	-3.84	6.68	1.80	-4.60	6.4
	UE4	-4.06	-6.20	2.15	-4.50	-6.50	2.0
U2-a2	UE1	11.14	3.13	8.01	8.30	2.00	6.3
	UE2	5.28	1.15	4.13	2.20	0.92	1.28
	UE3	11.14	3.18	7.97	8.90	2.40	6.5
	UE4	4.89	1.22	3.67	2.28	0.70	1.58
U2-b1	UE1	13.49	7.99	5.50	11.20	6.50	4.7
	UE2	8.22	6.15	2.07	5.70	5.20	0.50
	UE3	13.57	8.09	5.49	11.10	6.40	4.7
	UE4	8.47	6.13	2.34	5.80	5.00	0.8
U2-b2	UE1	6.66	2.39	4.27	4.60	1.28	3.32
	UE2	1.47	-0.20	1.67	0.20	-1.10	1.30
	UE3	6.51	2.32	4.19	4.40	1.30	3.10
	UE4	1.28	-0.21	1.49	-0.10	-1.10	1.0
U2-c	UE1	2.70	-1.31	4.02	0.60	-1.70	2.30
	UE2	5.20	-0.52	5.72	1.90	-1.00	2.90
	UE3	2.86	-1.42	4.28	1.90	-1.40	3.3
	UE4	5.26	-0.65	5.91	2.00	-1.60	3.6
U2-d	UE1	11.05	0.62	10.42	10.00	0.05	9.95
	UE2	-4.10	-6.30	2.20	-5.8	-6.30	0.5
	UE3	10.73	0.30	10.44	9.60	0.35	9.25
	UE4	-3.98	-6.14	2.16	-5.7	-6.30	0.6

Table 6.2.2-5: Companies' averaged performance gain of IC over baseline receiver, required SINR at 85 % TP

	Case Num	Average SINR gain (dB)			
		UE1	UE2	UE3	UE4
Equal SNR	E1-a1	2.8	3.0		
	E1-a2	2.6	2.6		
	E1-b1	1.6	1.6		
	E1-b2	1.6	1.6		
	E1-c	2.5	2.7		
	E2-a1	3.8	4.2	3.9	3.8
	E2-a2	4.8	4.8	4.6	4.7
	E2-b1	2.8	2.9	2.6	2.9
Unequal SNR	E2-b2	2.2	2.2	2.2	2.2
	U1-a1	5.0	1.3		
	U1-a2	4.9	1.0		
	U1-b1	3.9	0.3		
	U1-b2	3.2	0.6		
	U1-c	4.4	1.1		
	U1-d	2.3	3.2		
	U1-e	7.1	0.3		
	U2-a1	6.7	2.1	6.7	2.0
	U2-a2	7.4	3.3	7.4	3.0
	U2-b1	5.2	1.6	5.1	1.7
	U2-b2	4.0	1.4	3.9	1.3
	U2-c	3.8	5.1	4.1	5.2
	U2-d	10.3	1.9	10.0	1.7

Table 6.2.2-6: Performance comparison for baseline and reference receiver with and without TO/FO handling, required SINR at 85 % TP (Nokia, Alcatel-Lucent Shanghai Bell)

Case Num	Baseline receiver (dB)			IC receiver (dB)		
	TO/FO handled	TO/FO not handled	Loss due to not handling TO/FO	TO/FO handled	TO/FO not handled	Loss due to not handling TO/FO
E2-a1	1.57	2.83	1.26	-2.82	-1.58	1.24
E2-b1	11.03	12.08	1.05	8.52	10.48	1.96

6.3 Summary of link level evaluation

According to the above simulation results without time and frequency offset, the link performance gain of IC receiver over baseline receiver can be summarized as follows:

- For 2Rx equal SNR scenario:
 - The average IC gain for cases with EPA5 serving channel and high interference level is 2.7 ~ 3.1 dB from per UE perspective (case E1-a1, E1-a2, E1-c).
 - The average IC gain for cases with EVA70 serving channel and low interference level is 1.6 ~ 1.8 dB from per UE perspective (case E1-b1, E1-b2).
 - There is no obvious difference in terms of IC gain between UE1 and UE2.
- For 4Rx equal SNR scenario:
 - The average IC gain for cases with EPA5 serving channel and high interference level is 3.7 ~ 5.3dB from per UE perspective (case E2-a1, E2-a2).
 - The average IC gain for cases with EVA70 serving channel and low interference level is 2.3 ~ 2.8dB from per UE perspective (case E2-b1, E2-b2).
 - There is no obvious difference in terms of IC gain among the 4 UEs.
- For 2Rx unequal SNR scenario (the SNR of UE1 is 3 dB lower than that of UE2):
 - If all UEs use the same MCS
 - o The average IC gain for cases with EPA5 serving channel and high interference level is 4.9 ~ 5.3 dB and 1.4 ~ 1.8 dB for UE1 and UE2 respectively (case U1-a1, U1-a2, U1-c).
 - o The average IC gain for cases with EVA70 serving channel and low interference level is 3.4 ~ 3.9 dB and 0.3 ~ 0.4 dB for UE1 and UE2 respectively (case U1-b1, U1-b2).
 - If UEs with different SNR use different MCS
 - o When MCS 10 is used for UE1 and MCS 15 is used for UE2, with EPA5 serving channel and high interference level, the average IC gain is 2.3 and 3.4 dB for UE1 and UE2 respectively (case U1-d).
 - o When MCS 15 is used for UE1 and MCS 10 is used for UE2, with EPA5 serving channel and high interference level, the average IC gain is 7.3 and 0.3 dB for UE1 and UE2 respectively (case U1-e).
- For 4Rx unequal SNR scenario (the SNR of UE1/3 is 3 dB lower than that of UE2/4):
 - If all UEs use the same MCS
 - o The average IC gain for cases with EPA5 serving channel and high interference level is 6.5 ~ 7.9 dB and 2.1 ~ 3.4 dB for UE1/3 and UE2/4 respectively (case U2-a1, U2-a2).
 - o The average IC gain for cases with EVA70 serving channel and low interference level is 4.1 ~ 5.4 dB and 1.4 ~ 1.8 dB for UE1/3 and UE2/4 respectively (case U2-b1, U2-b2).
 - If UEs with different SNR use different MCS

- o When MCS 10 is used for UE1/3 and MCS 15 is used for UE2/4, with EPA5 serving channel and high interference level, the average IC gain is 4.2 ~ 4.3 and 5.1 ~ 5.2 dB for UE1/3 and UE2/4 respectively (case U2-c).
- o When MCS 15 is used for UE1/3 and MCS 10 is used for UE2/4, with EPA5 serving channel and high interference level, the average IC gain is 10.7 ~ 10.9 dB and 1.9 ~ 2.0 dB for UE1/3 and UE2/4 respectively (case U2-d).

According to the above simulation results with time and frequency offset,

- The performance difference compared to the cases without TO/FO (in section 6.2.1) is minor.
- The observed IC gain is very similar to that from the cases without TO/FO (in section 6.2.1).

7 Conclusions

This technical report has documented the RAN4 study on interference cancellation receiver for LTE BS. The major work includes the determination of typical network scenarios and serving/interfering channels, definition of reference receiver structures, and link-level performance evaluations.

Homogeneous and heterogeneous network scenarios are introduced with considerations of interference among data channels (PUSCH).

For the reference receiver, CW-IC receiver is used for intra-cell inter-user interference mitigation. In multi-cell scenario, for both baseline and reference receivers, inter-cell interference suppression with MMSE-IRC is used.

Link-level simulations are performed to evaluate the performance gain of reference receiver over baseline receiver. 22 simulation cases with different Rx antenna numbers, propagation conditions, MCS levels and inter-cell interference levels are evaluated. The simulation results without time and frequency offset can be summarized as follows:

- For 2Rx equal SNR scenario:
 - The average IC gain for cases with EPA5 serving channel and high interference level is 2.7 ~ 3.1 dB from per UE perspective (case E1-a1, E1-a2, E1-c).
 - The average IC gain for cases with EVA70 serving channel and low interference level is 1.6 ~ 1.8 dB from per UE perspective (case E1-b1, E1-b2).
 - There is no obvious difference in terms of IC gain between UE1 and UE2.
- For 4Rx equal SNR scenario:
 - The average IC gain for cases with EPA5 serving channel and high interference level is 3.7 ~ 5.3dB from per UE perspective (case E2-a1, E2-a2).
 - The average IC gain for cases with EVA70 serving channel and low interference level is 2.3 ~ 2.8dB from per UE perspective (case E2-b1, E2-b2).
 - There is no obvious difference in terms of IC gain among the 4 UEs.
- For 2Rx unequal SNR scenario (the SNR of UE1 is 3 dB lower than that of UE2):
 - If all UEs use the same MCS
 - o The average IC gain for cases with EPA5 serving channel and high interference level is 4.9 ~ 5.3 dB and 1.4 ~ 1.8 dB for UE1 and UE2 respectively (case U1-a1, U1-a2, U1-c).
 - o The average IC gain for cases with EVA70 serving channel and low interference level is 3.4 ~ 3.9 dB and 0.3 ~ 0.4 dB for UE1 and UE2 respectively (case U1-b1, U1-b2).
 - If UEs with different SNR use different MCS
 - o When MCS 10 is used for UE1 and MCS 15 is used for UE2, with EPA5 serving channel and high interference level, the average IC gain is 2.3 and 3.4 dB for UE1 and UE2 respectively (case U1-d).

- o When MCS 15 is used for UE1 and MCS 10 is used for UE2, with EPA5 serving channel and high interference level, the average IC gain is 7.3 and 0.3 dB for UE1 and UE2 respectively (case U1-e).
- For 4Rx unequal SNR scenario (the SNR of UE1/3 is 3 dB lower than that of UE2/4):
 - If all UEs use the same MCS
 - o The average IC gain for cases with EPA5 serving channel and high interference level is 6.5 ~ 7.9 dB and 2.1 ~ 3.4 dB for UE1/3 and UE2/4 respectively (case U2-a1, U2-a2).
 - o The average IC gain for cases with EVA70 serving channel and low interference level is 4.1 ~ 5.4 dB and 1.4 ~ 1.8 dB for UE1/3 and UE2/4 respectively (case U2-b1, U2-b2).
 - If UEs with different SNR use different MCS
 - o When MCS 10 is used for UE1/3 and MCS 15 is used for UE2/4, with EPA5 serving channel and high interference level, the average IC gain is 4.2 ~ 4.3 and 5.1 ~ 5.2 dB for UE1/3 and UE2/4 respectively (case U2-c).
 - o When MCS 15 is used for UE1/3 and MCS 10 is used for UE2/4, with EPA5 serving channel and high interference level, the average IC gain is 10.7 ~ 10.9 dB and 1.9 ~ 2.0 dB for UE1/3 and UE2/4 respectively (case U2-d).

The simulation results with time and frequency offset can be summarized as follows:

- The performance difference compared to the cases without time and frequency offset is minor.
- The observed IC gain is very similar to that from the cases without time and frequency offset.

Considering the above performance evaluation results as well as the test coverage / workload, for the performance requirements in the follow-up work item, it is recommended to:

- Model time offset and frequency offset
- Use the following test metric:
 - SINR at 80% of maximum sum throughput of all the intra-cell UEs
- Introduce the following test cases:

Table 7-1: Recommended test cases for the follow-up work item

Case No.	SNR distribution	Rx antenna	No. of UEs	Propagation condition (intra-cell UEs, inter-cell UEs)	MCS level (intra-cell UEs)	Inter-cell interference scenario
E1-c (Note 1)	equal average SNR	2 Rx	2 UEs	(EPA5 low, ETU5 low)	MCS 21	DIP1 = -0.43 dB
E2-b1		4 Rx	4 UEs	(EVA70 low, ETU70 low)	MCS 15	DIP1 = -5.45 dB
U1-b1	unequal average SNR	2 Rx	2 UEs	(EVA70 low, ETU70 low)	MCS 15	DIP1 = -5.45 dB
U2-c		4 Rx	4 UEs	(EPA5 low, ETU5 low)	MCS 10 for UE1, 3 MCS 15 for UE2, 4	DIP1= -0.43 dB
Note 1: For case E1-c with 15MHz and 20MHz channel bandwidth, 50 resource blocks in the middle of the channel bandwidth is allocated in the test.						

Annex A:

Change history

Date	Meeting	TDoc	CR	Rev	Cat	Subject/Comment	New version
2016-10	RAN4 #80bis	R4-167863				TR skeleton	0.0.1
2017-02	RAN4 #82	R4-1700738				Incorporated the following TP agreed in RAN4 #81: – R4-1610864, TP: deployment scenarios for BS-IC	0.1.0
2017-03	RAN #75/ RAN4 #82bis	RP-170160/ R4-1702823				Incorporated the following TP agreed in RAN4 #82: – R4-1700739, TP on BS IC intra-cell interference scenario – R4-1700740, TP on BS IC receiver structure – R4-1700741, TP on BS IC inter-cell interference model	1.0.0
2017-05	RAN4 #83	R4-1704559				Incorporated the following TP agreed in RAN4 #82bis: – R4-1702824, TP on BS IC link level evaluation parameters – R4-1704151, TP on BS IC link level simulation results – R4-1704121, TP on simulation results for BS IC with TO/FO	1.1.0
2017-06	RP-76	RP-170937				Incorporated the following TP agreed in RAN4 #83: – R4-1704560, TP on additional simulation results for BS IC without TO/FO, RAN4 #83, May 2017. – R4-1705992, TP on simulation results updates for 2Rx and 4Rx without TO FO, RAN4 #83, May 2017. – R4-1705731, TP on updated simulation results for BS IC with TO/FO, RAN4 #83, May 2017. – R4-1705993, TP on simulation results addition for 2Rx and 4Rx with TO FO, RAN4 #83, May 2017. – R4-1706007, TP on TR conclusions, RAN4 #83, May 2017. – R4-1704561, Editorial TP for TR 36.766, RAN4 #83, May 2017.	2.0.0
2017-06	RP-76					TR Approved	15.0.0