

3GPP TSG-RAN Meeting #76
West Palm Beach, U.S.A, June 5th – 8th, 2017

RP-171147



Motivation for WI Low Complexity Higher Order MIMO



■ Motivation

- Bring more 4-Rx capable UEs into the **ecosystem**, therefore UEs with a new capability are introduced

■ 4-Rx and 4x4 MIMO (Rank-4)

- Highest probability of 4x4 MIMO (Rank-4 pre-coded at eNB) is when at least DL Rank-4 QPSK has better scattering multipath channel metrics than Rank-2 64QAM
- Based on SNR vs RSSI performance of a UE, and majority of mobile environments, Rank-4 or 3 is highly unlikely for $UL > 0\text{dBm}$ (or $DL < -55\text{dBm}$)
- At low DL power levels (high UL power) 4-Rx used in Rank-2 MRC type combining rather than pure Rank-4

■ Benefits

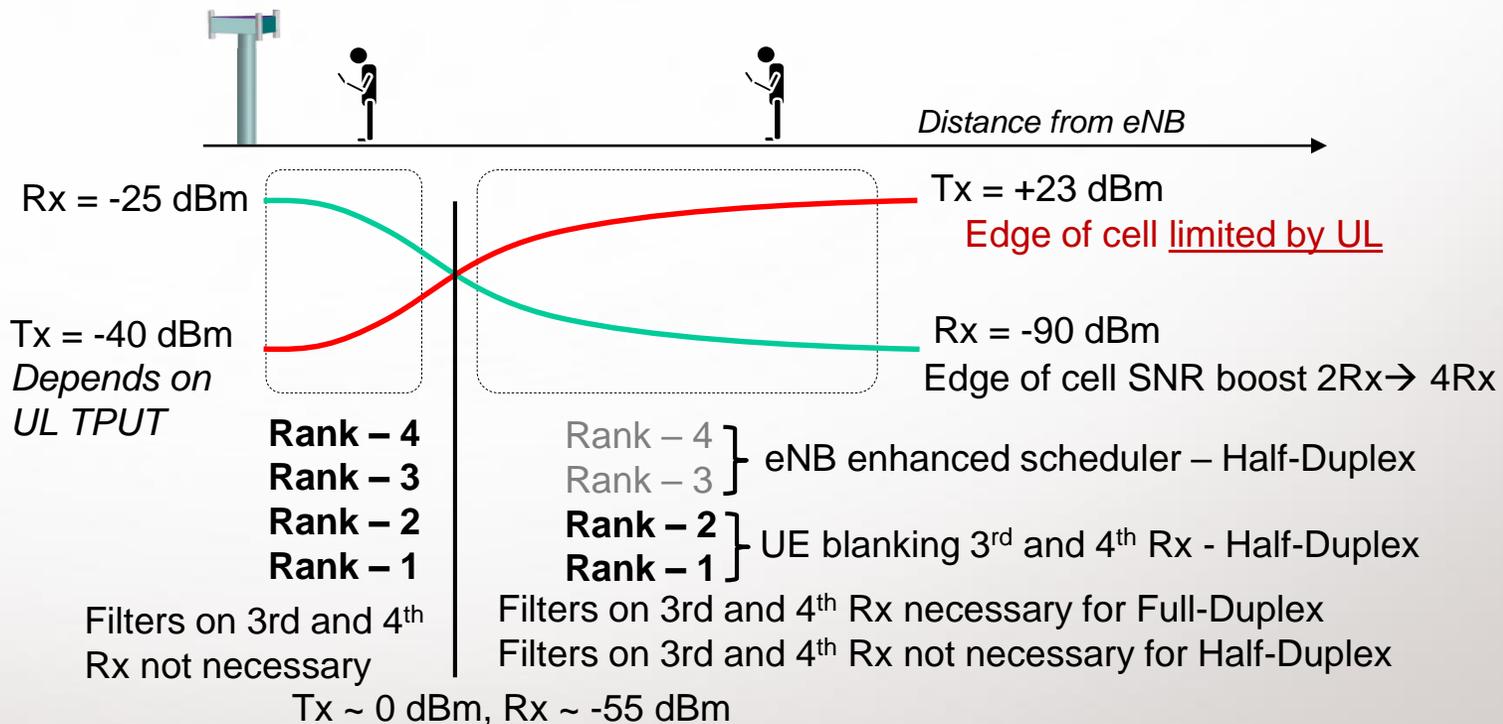
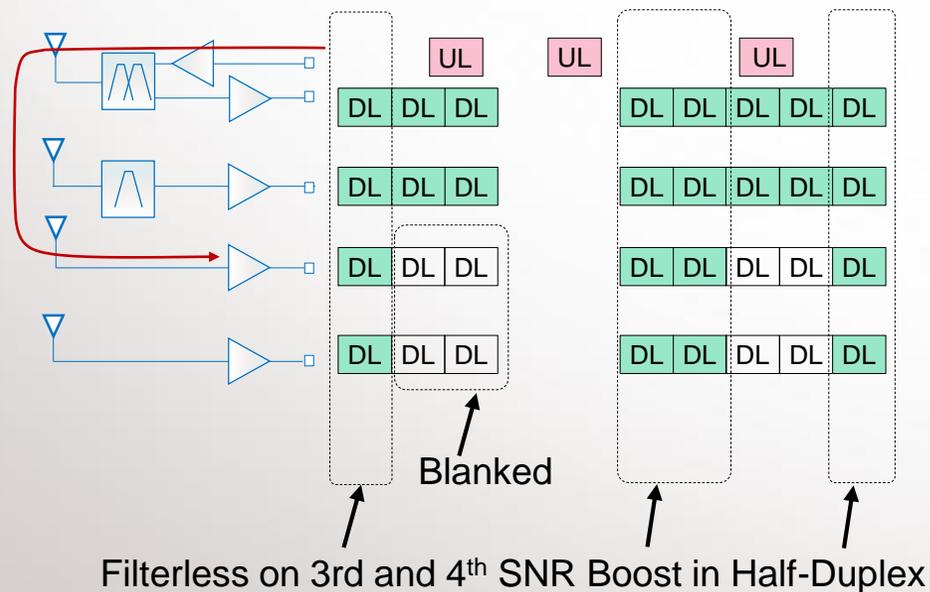
- Increased capacity in a Cell since more and more UEs are 4-Rx Capable
- Lower cost UEs, more space to implement low envelop correlation Antennas needed for better Rank-4 performance

■ Implementation

- UE
 - (a) Only 3rd and 4th Receivers do not have RF filters before LNA: more volume for efficient 4Rx ANTs, lower cost
 - (b) UE will opportunistically choose Half-Duplex via blanking 3rd and 4th Rx
 - legacy 2 Rx performance is guaranteed, 4-Rx performance boost when UL SFs not colliding with DL SFs in time
- eNB
 - (a) When $UL > 0\text{dBm}$ (or $DL < -55\text{dBm}$) and when Rank-4 or Rank-3 is scheduled in DL, proposal is to implement enhanced scheduler to create Half-Duplex
- Signaling - Add capability Bit to identify “lower complexity higher order MIMO” Devices
- 2 CQI processes tracking subframes with and without UE Tx enable automatic link adaptation

4Rx UE functionality in the Network

- **All 4 receive chains are used** to boost SNR in any given Rank
 - e.g. Rank-2 can use all 4 Rx to boost SNR compared with 2 Rx
- for $UL < 0\text{dBm}$ simultaneous UL-DL allocation on 3rd and 4th Rx allowed for most field condition
- for $UL > 0\text{dBm}$, no simultaneous UL-DL allocation
 - Rank-4, Rank-3 scheduled in DL cases, proposal to implement eNB enhanced Scheduler to create Half-Duplex
 - Rank-2, Rank-1 scheduled in DL cases, UE will opportunistically choose Half-Duplex via blanking 3rd and 4th Rx
 - legacy 2 Rx performance is guaranteed, 4Rx performance boost when UL SFs not colliding with DL SFs in time.
 - Knowledge of UL grant $\sim 3\text{ms}$ prior to blanking

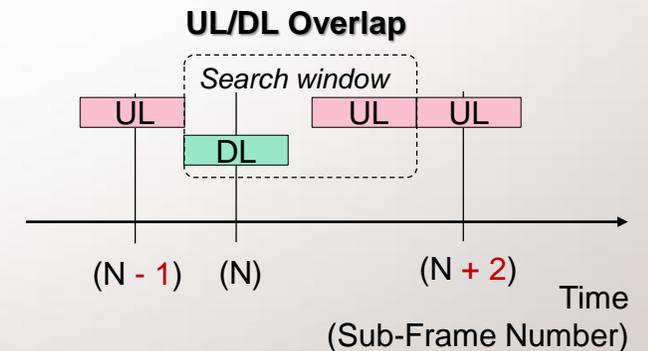
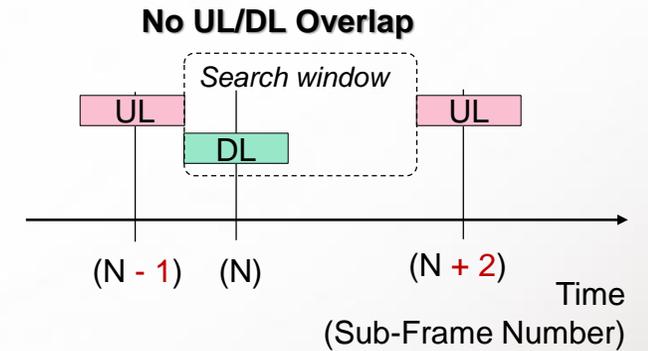


UL-DL collision in time analysis based on field logs (Rank 2 only)

- For TX powers larger than 0dBm (where Rx SNR degradation increases), Average UL-DL collision in time is 31%
- 4-Rx will be used in MRC type combing scheme to boost Rank-2 SNR when Rank-4 is not scheduled in DL which is the likely case for UL >0dBm, hence filter-less 3rd and 4th Rx can still benefit from SNR boost in no-UL-DL overlap SFs

Used Case	Location	All Tx Power Levels			Tx Power > 0dBm		
		Tx-PDSCH collision rate (%)	PUCCH-PDSCH collision rate (%)	PUSCH-PDSCH collision rate (%)	Tx-PDSCH collision rate (%)	PUCCH-PDSCH collision rate (%)	PUSCH-PDSCH collision rate (%)
FTP	NJ	80.0%	44.0%	35.1%	60.8%	26.5%	33.3%
FTP	SCL	72.9%	54.3%	18.6%	49.5%	31.7%	17.8%
FTP	SD	58.3%	43.5%	14.8%	21.0%	9.5%	11.5%
FTP	DAL	83.6%	65.1%	16.4%	58.6%	41.9%	14.9%
FTP	DAL	86.9%	73.4%	13.2%	9.7%	2.5%	7.0%
FTP	NYC	92.2%	80.2%	11.9%	14.2%	8.0%	6.2%
APPs	SD	62.8%	37.6%	25.2%	28.1%	9.3%	18.7%
Time weighted		86.9%	70.7%	15.5%	31.1%	19.0%	11.4%
Note 1:	Apps include Google MAPs Drive test, UTUBE, Netflix, Google hangout video chat, game of war						
Note 2:	SRS collisions are included in the total Tx-PDSCH collision rate.						

Criteria for searching for UL/DL time-overlap % in field logs

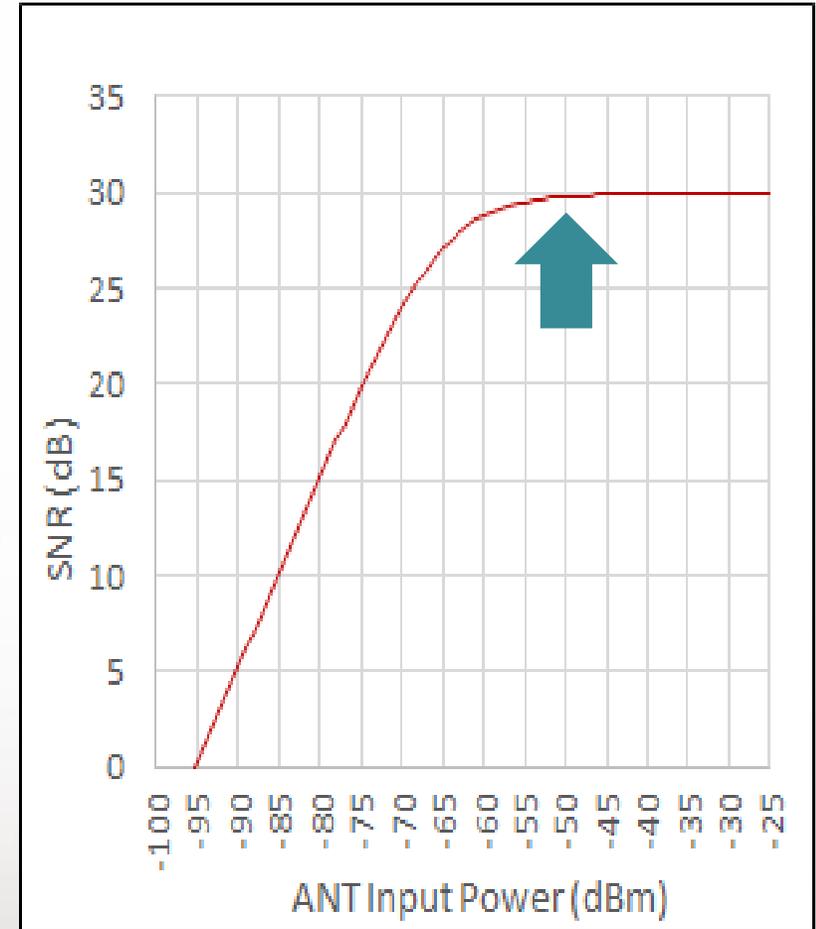
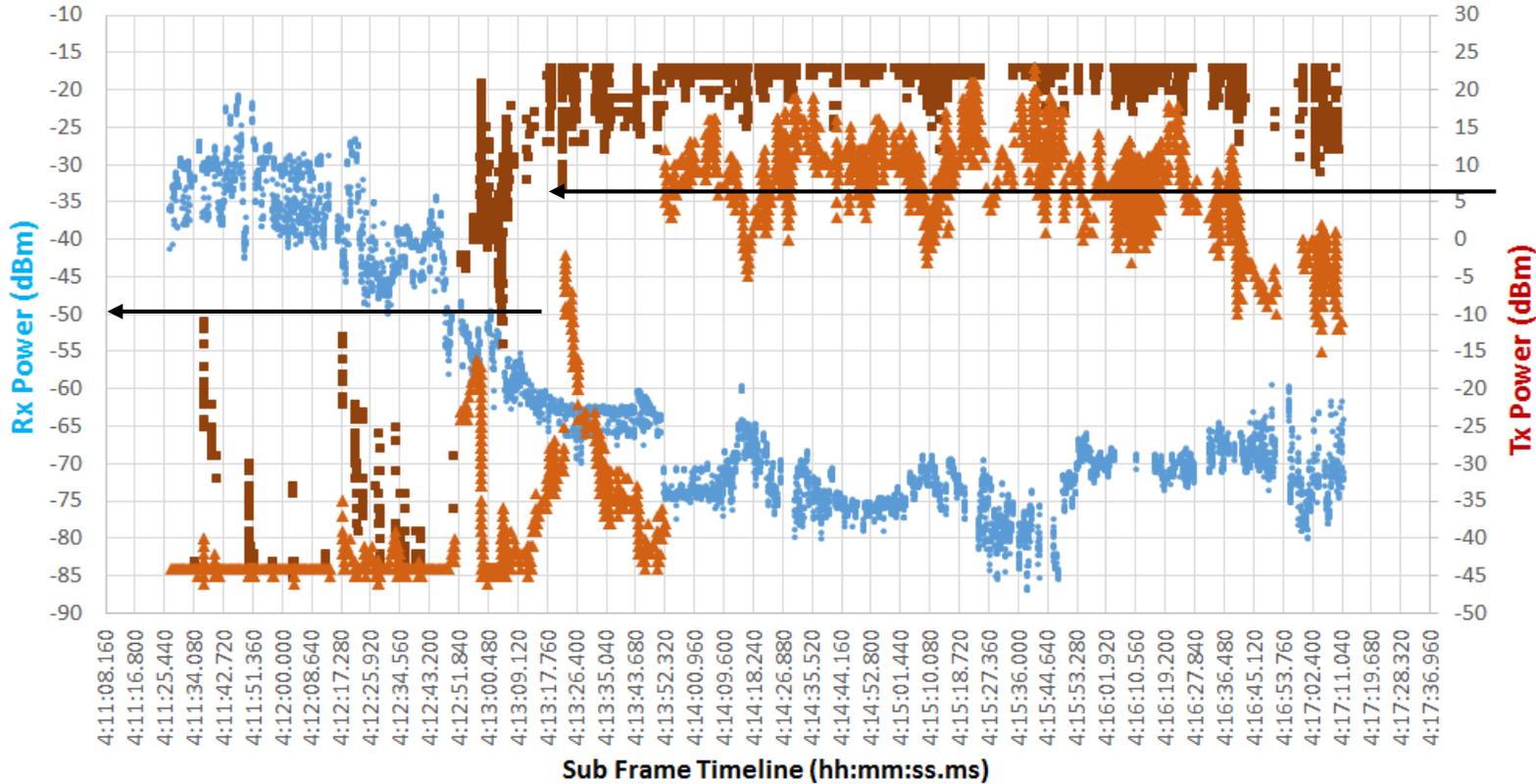


UL power level and relationship to DL power level and DL SNR

- UL power level is related to DL power level and UL TPUT
 - UL > 0dBm typically crosses with DL < -55dBm
- DL < -55dBm like hood of Rank-4 is rare due to poor SNR from increasing Thermal Noise dominance

Google Maps Drive Test on major US carrier

- LTE_LL1_Rx_AGC_vs__Time_PCCOnline-DRXMeasuredInbandRSSIRx0
- Actual PUSCH Tx Power (dBm)
- ▲ Actual PUCCH Tx Power (dBm)

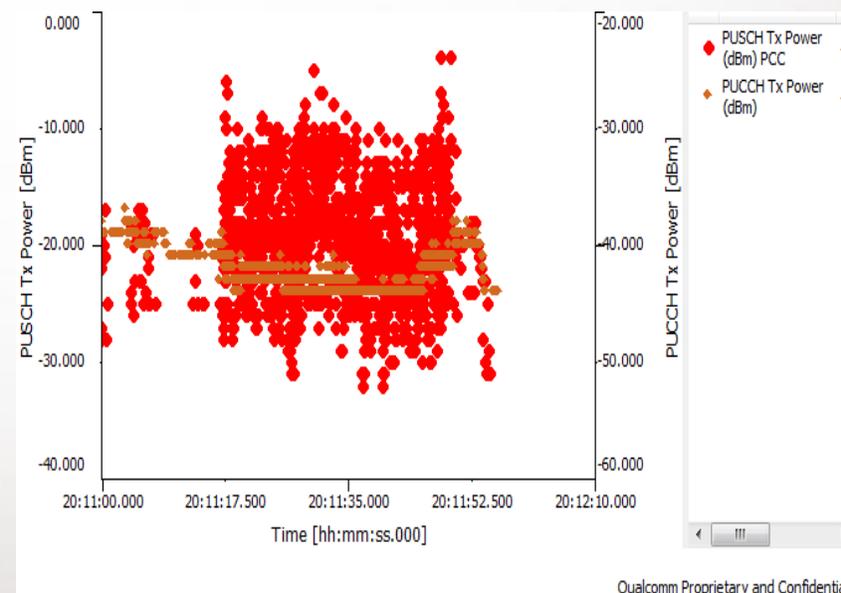
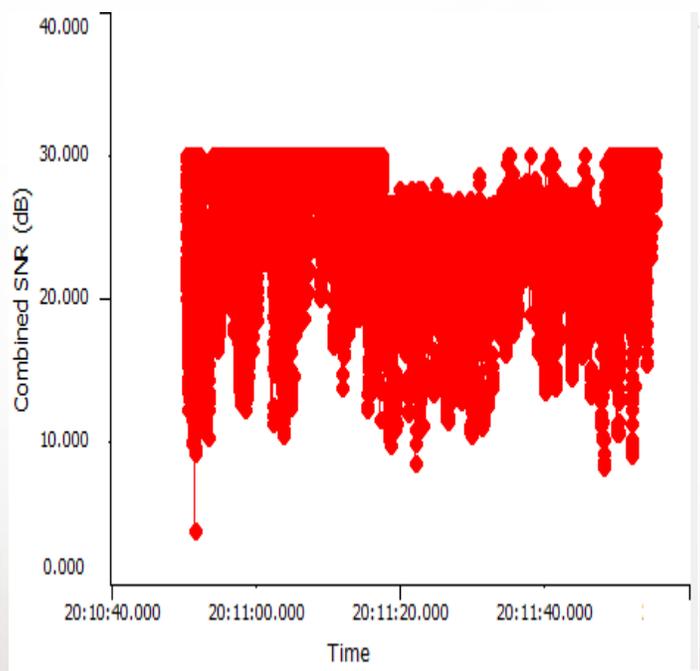
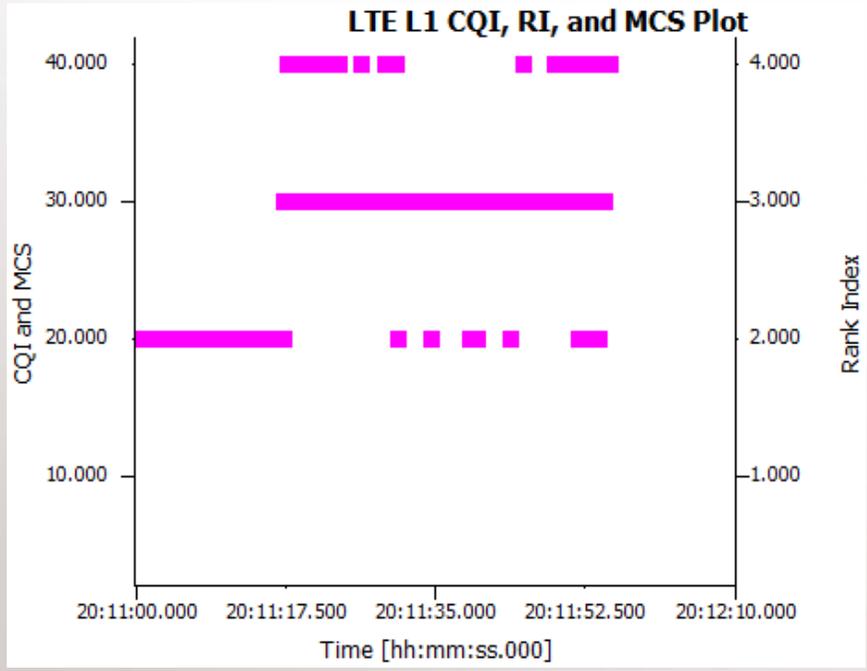
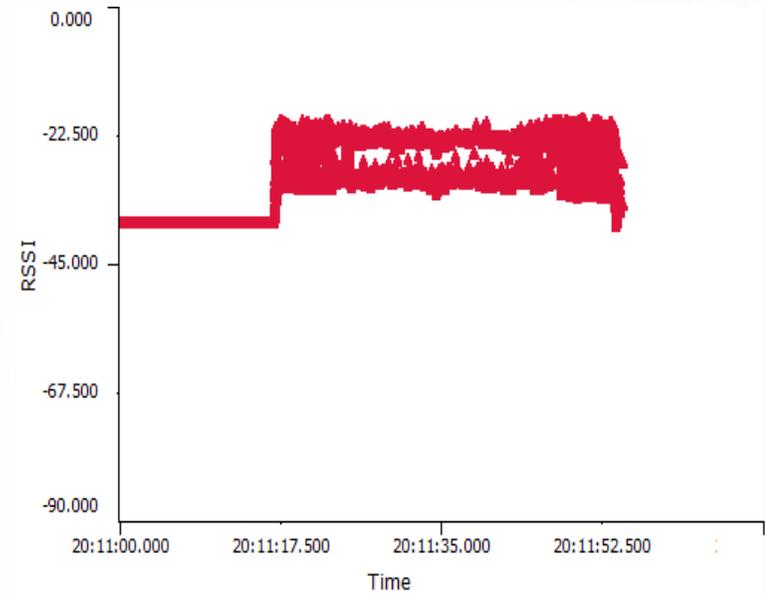


Field Log on 4x4 MIMO (example log from Seattle)

Observations

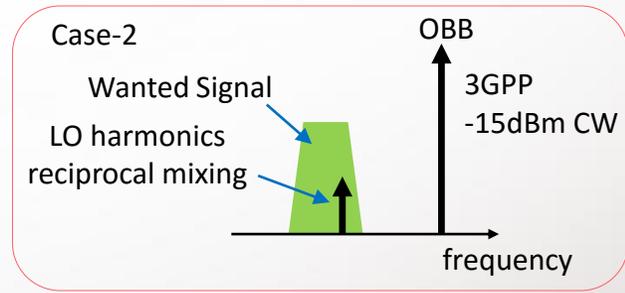
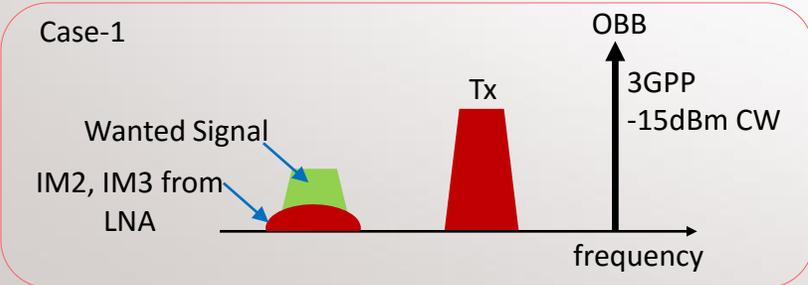
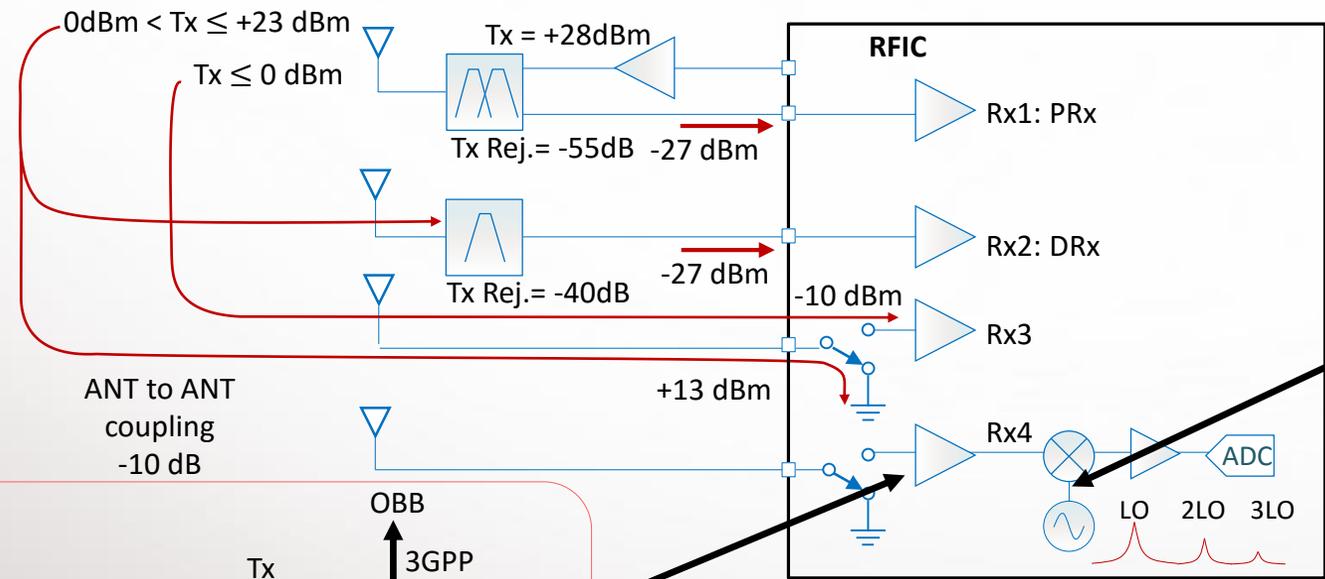
- Difficulty in maintaining Rank-4 in good SNR strong DL levels
- High Tx-Rx collision rate is not an issue since UL level is below 0dBm

	tx_pdsch_collide	pucch_pdsch_collide	pusch_pdsch_collide	srs_pdsch_collide	tx_rx_collide_greater than 0dBm
OperatorX-SEATTLE_RANK4	488	408	67	13	0
	66.5%	55.6%	9.1%	1.8%	
OperatorX-SEATTLE_ALL	9432	8195	1198	39	0
	74.4%	64.7%	9.5%	0.3%	



Filter-less 3rd and 4th Receiver blocking

- OOB -15dBm 3GPP exceptions
 - with filters, exceptions are needed at LNA IIP2 frequencies
 - 24 exceptions may be used at LNA IIP2 (OOB = Tx+Rx) and IIP3(OOB = 2Tx-Rx)
 - Tx **-10dBm** instead of +20dBm in 3GPP OOB test case for <REFSENS> + 6dB
- Adjacent UE 1m away: +23dBm - Path Loss 38dB = -15dBm at 3rd and 4th Rx < -10dBm limit
- No impact to IBB since IBB blockers are inside filter passband



Dual CQI process approach

- The UE will see different interference levels on different subframes
 - Subframes in which the UE is transmitting -> Self-interference can lead to de-sensitization of 3rd and 4th Rx so whether 3rd and 4th receive are usable depends on UE Tx power
 - Subframes in which the UE is not transmitting -> all 4Rx are usable
- Automatic link adaptation can be enabled if separate channel state feedback processes are used for these 2 types of subframes with different channel conditions
- UE maintains 2 CQI processes (similar to FeICIC or eIMTA):
 - one for subframes with Tx-Rx collisions (fallback to 2Rx when 3rd and 4th Rx are de-sensed)
 - one for subframes without Tx-Rx collisions (all 4 receivers usable all the time, even at cell edge)
- eNB knows when Tx-Rx collisions happen so it can schedule based on the right CQI
- eNB can maintain separate outer loops for the 2 CQI processes
- This solution enables automatic link adaptation and maximizes network capacity/performance
 - If the eNB scheduler can reduce the number of subframes in which the UE transmits, UE throughput and network capacity can be maximized

3GPP Specification Proposal

■ RAN4

- For such devices, introduce 2 REFSENS tests
 - +23 dBm Tx: **4Rx** UE's REFSENS is same as **2Rx** REFSENS
 - -20 dBm Tx: **4Rx** UE's REFSENS is same as **4Rx** REFSENS - *captures 4Rx benefits when UE is not transmitting while receiving*
- For such devices, OOB Range-3 spec <REFSENS> + 6dB likely to be met with -10dBm Tx since UE is in Half-Duplex mode

■ RAN2

- Add capability bit to identify “lower complexity higher order MIMO” devices per band

■ RAN1

- Introduce 2 CQI process

Thank You

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