3GPP RAN WG4 Meeting #76bis **R4- 156505**

Sophia Antipolis, France, 12 – 16 Oct, 2015

Source: Rohde&Schwarz, Keysight Technologies

Title: Averaging: Overview and Suggested Way-Forward

Agenda Item: 7.3.5 - Test case definitions [LTE_MIMO_OTA-Core]

Document for: Discussion

3GPP Harmonization Campaign

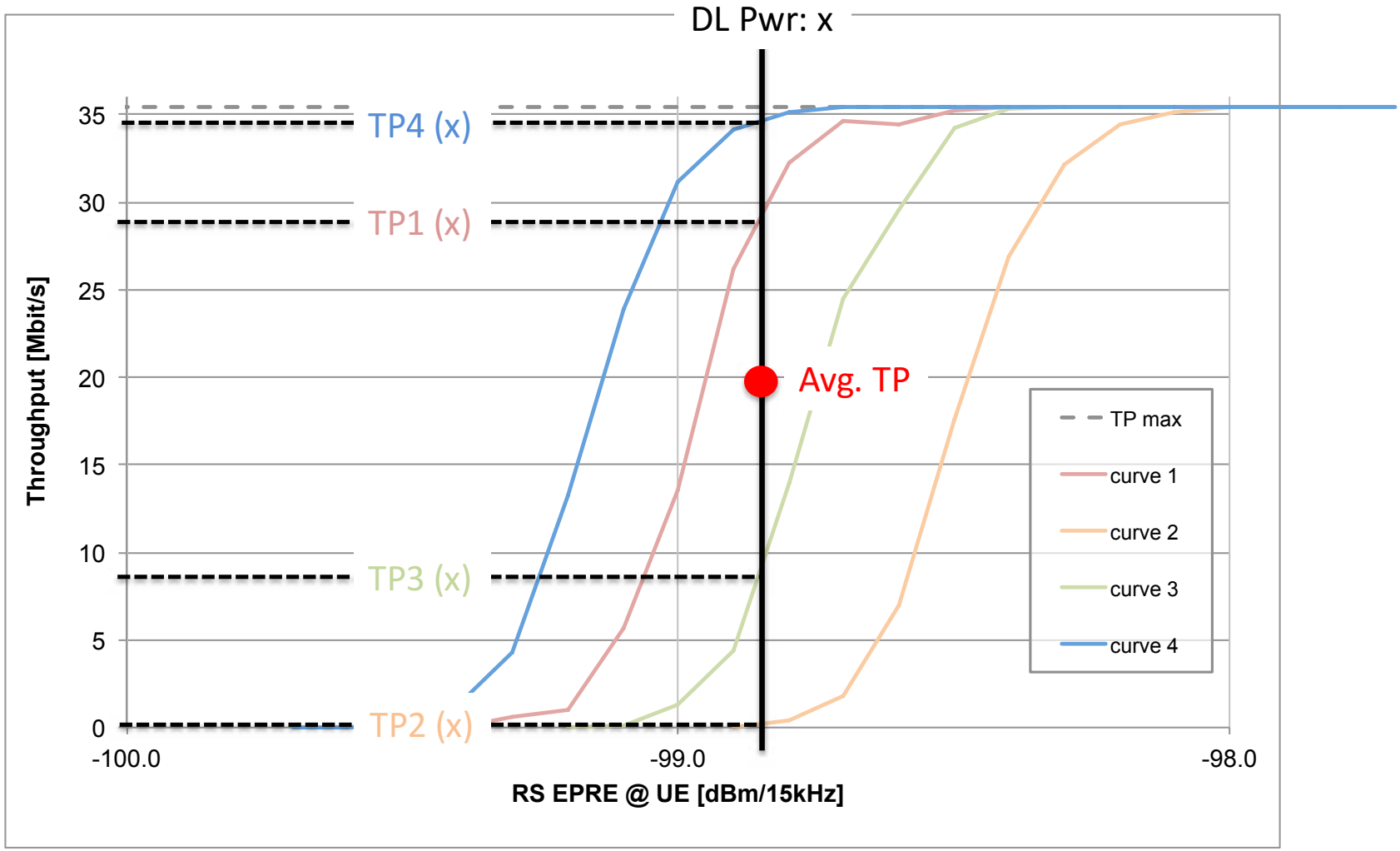
- This summer, 3GPP RAN4 [R4-152462] initiated a harmonization campaign with the 4 different methodologies considered: MPAC, RTS, RC&CE, RC
  - UE noise limited TM3 testing (TP vs RS EPRE)
  - Three different frequency bands and three UEs per band
  - AC methodologies: 8 different UE orientations with 12 AZ positions per orientation (96 individual curves)
  - RC methodologies:
    - Continuous and stepwise stirring modes (120 modes)
    - 400 and 20k subframes (SF) per power level and mode
- A lot of raw data has been made available [R4-155322]

Review of Averaging Approaches

- The following three averaging approaches were discussed previously [MOSG130704*]
  - TP Average
  - Regular DL Power Average
  - Inverse DL Power Average

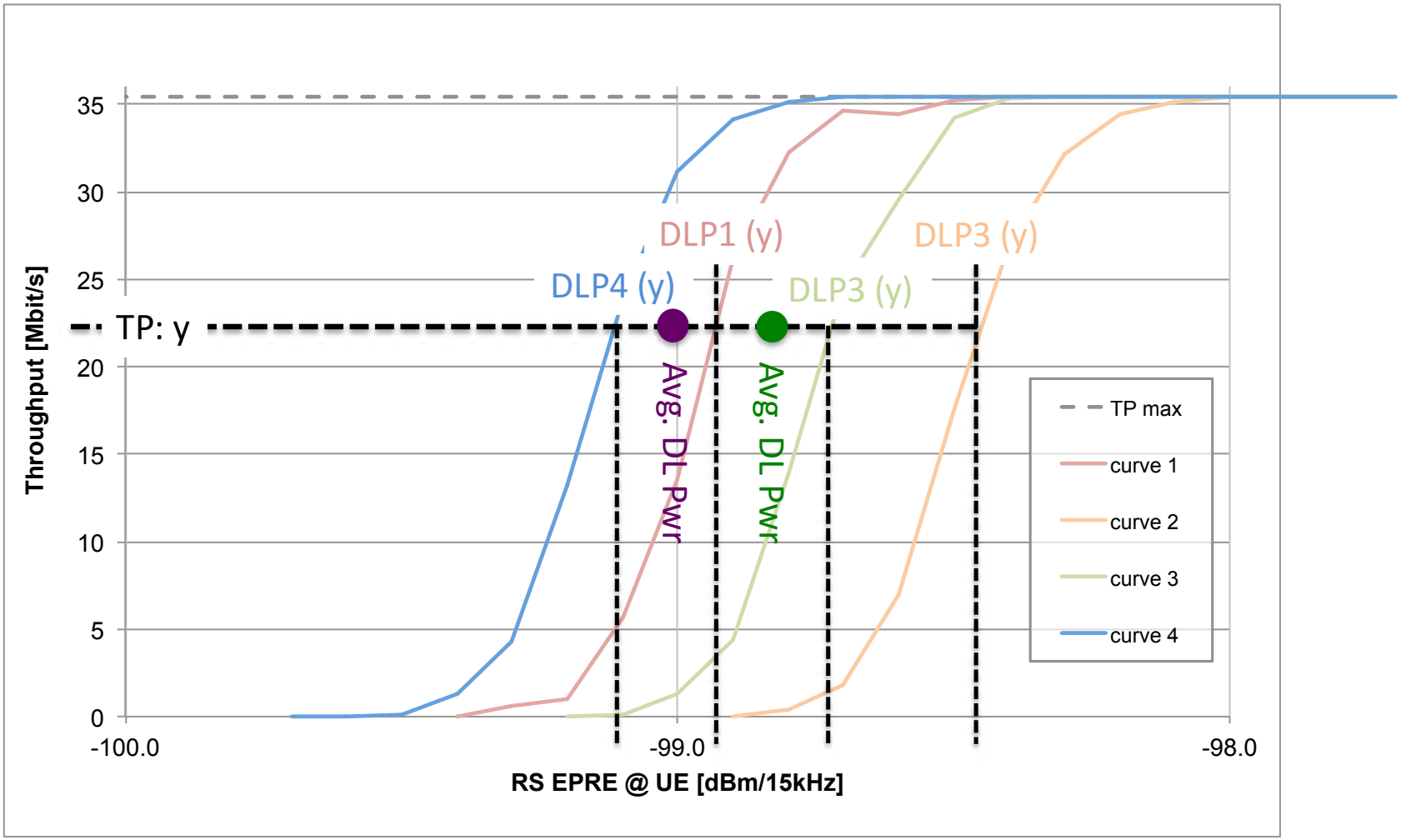
* This is a CTIA Sub-Working Group Document available to CTIA Sub-Working Group members

TP Average



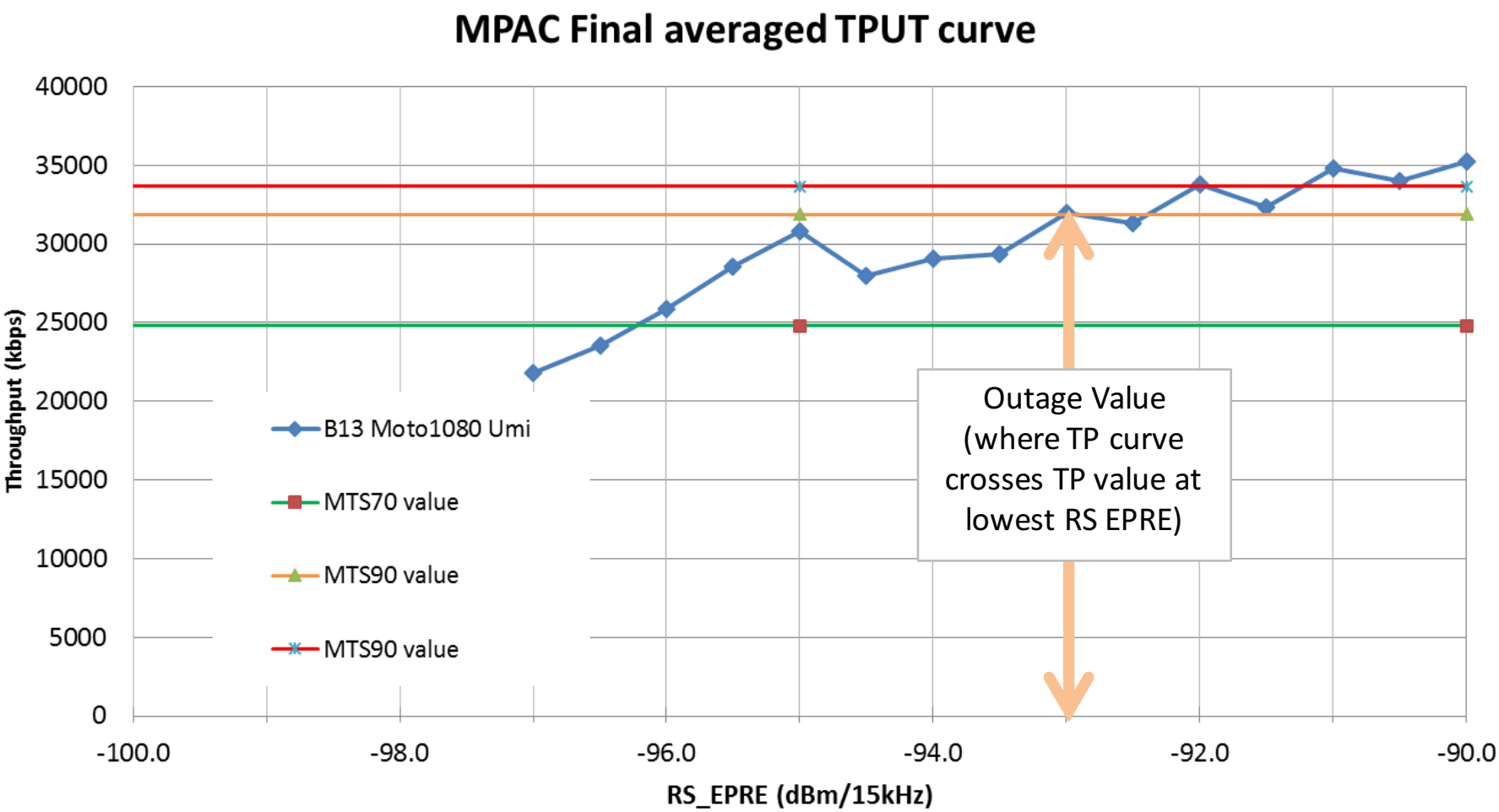
- AVG TP (x) = ¼ [TP1(x) + TP2(x) + TP3(x) + TP4(x)]

Average based on DL Pwr (DLP)



- Avg $DLP|_{reg}$ (y) = ¼ [DLP1(y) + DLP2(y) + DLP3(y) + DLP4(y)]
- Avg $DLP|_{inv}$ (y) = $\dfrac{4}{\dfrac{1}{DLP1(y)}+\dfrac{1}{DLP2(y)}+\dfrac{1}{DLP3(y)}+\dfrac{1}{DLP4(y)}}$

Outage Detection Algorithm



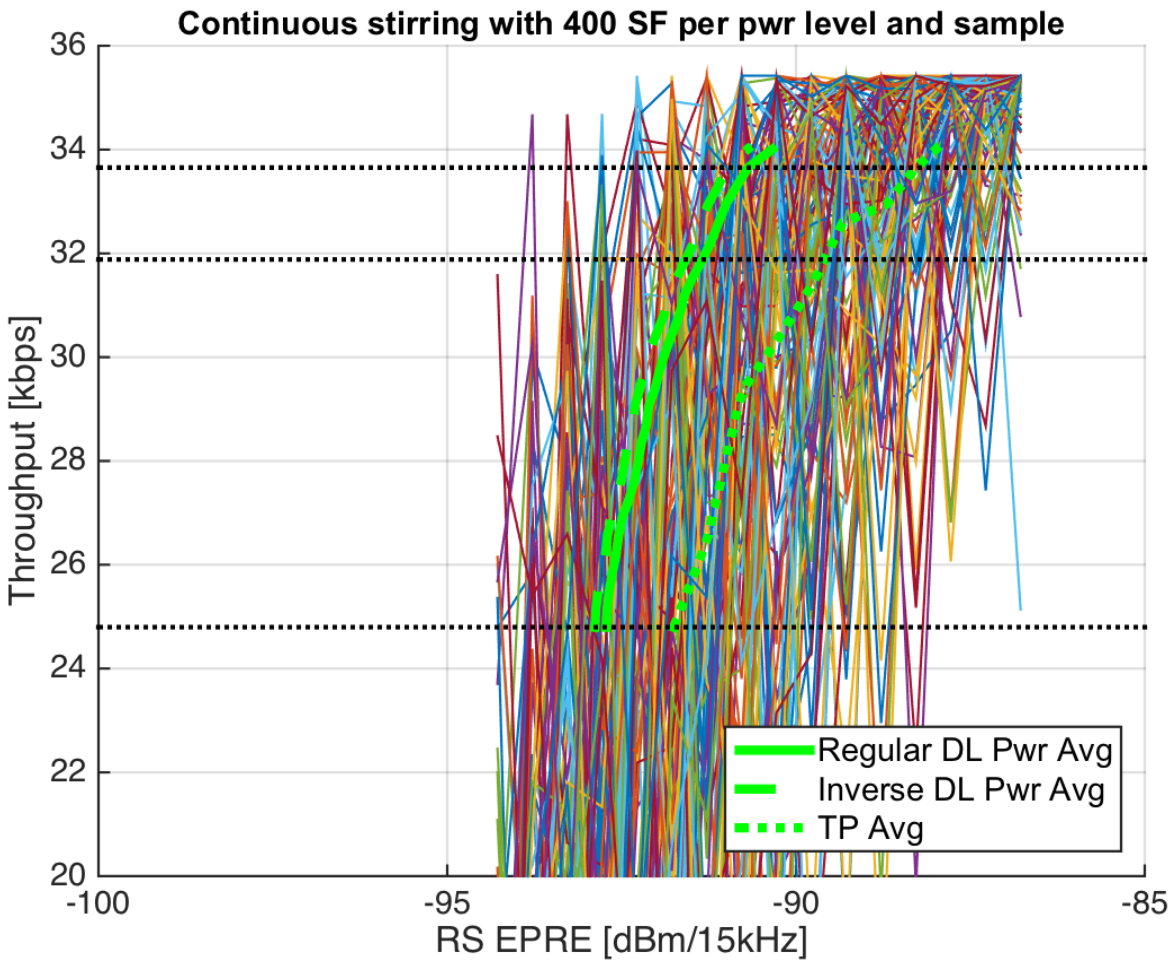
Objective

- Use some of the 3GPP RAN4 harmonization results to outline the various averaging approaches

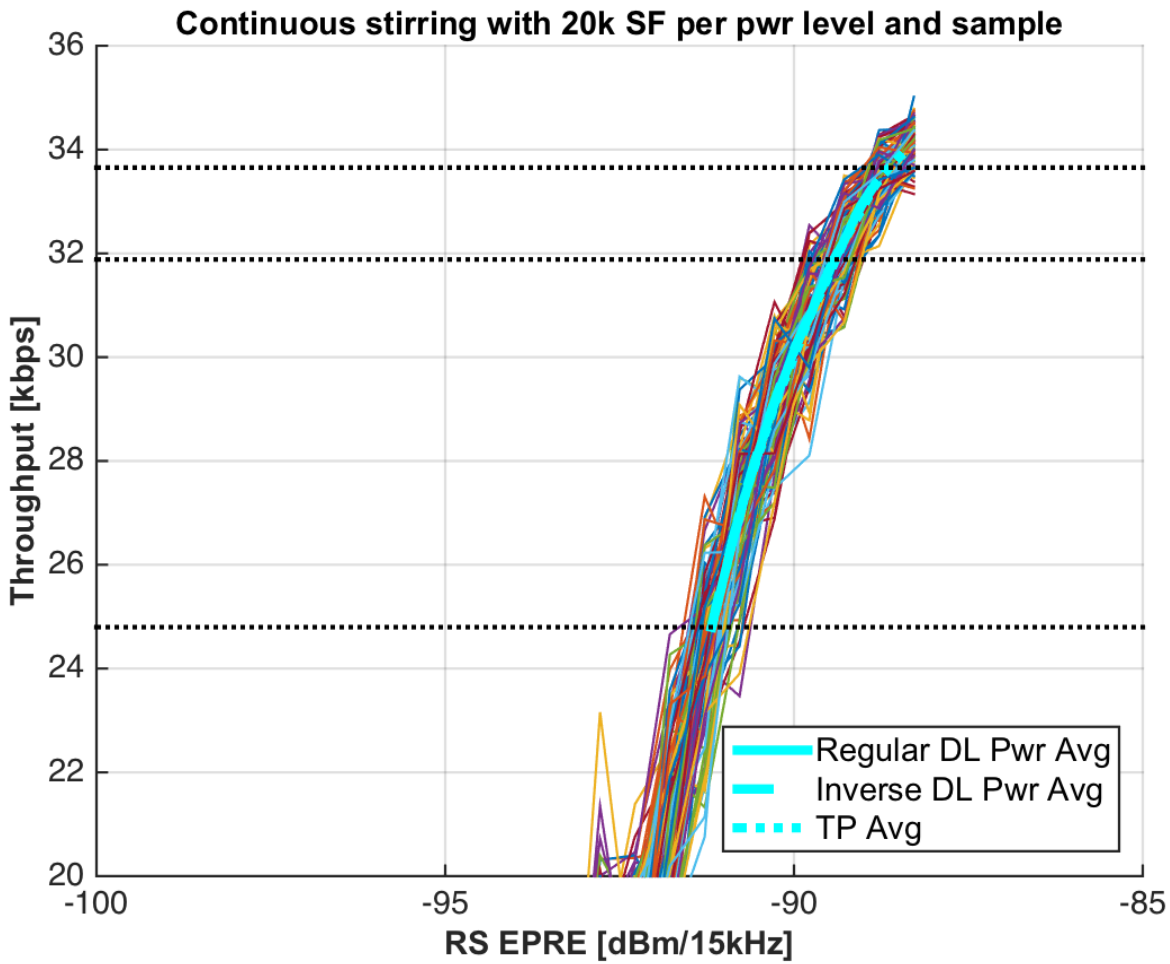
RC&CE Example

- In the following slides, averaging examples for the RC&CE results are presented
  - UE: Motorola 1080
  - Band: FDD13
  - Channel Model: UMa

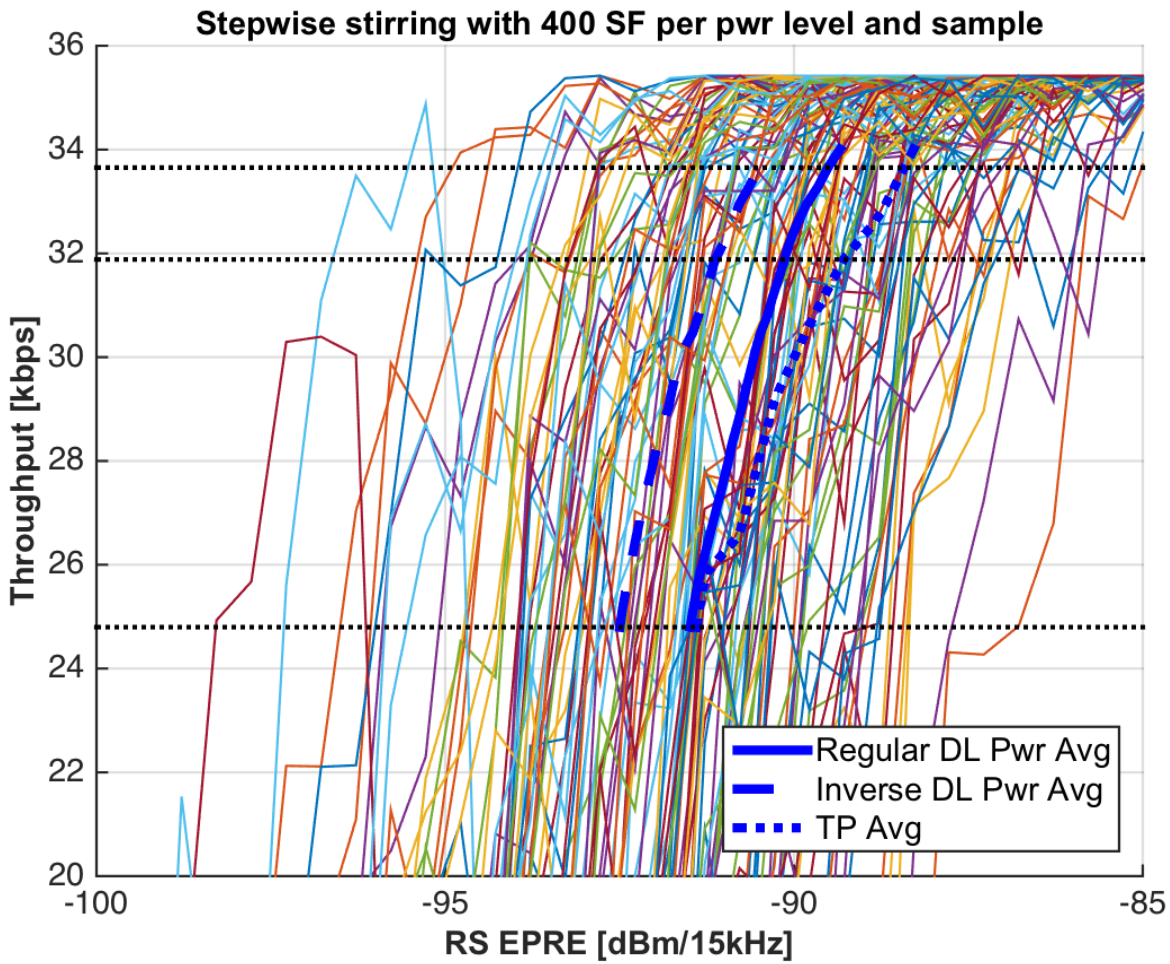
RC&CE


Continuous stirring with 400 SF per pwr level and sample
Throughput [kbps]
36
34
32
30
28
26
24
22
20
-100
-95
-90
-85
RS EPRE [dBm/15kHz]
Regular DL Pwr Avg
Inverse DL Pwr Avg
TP Avg

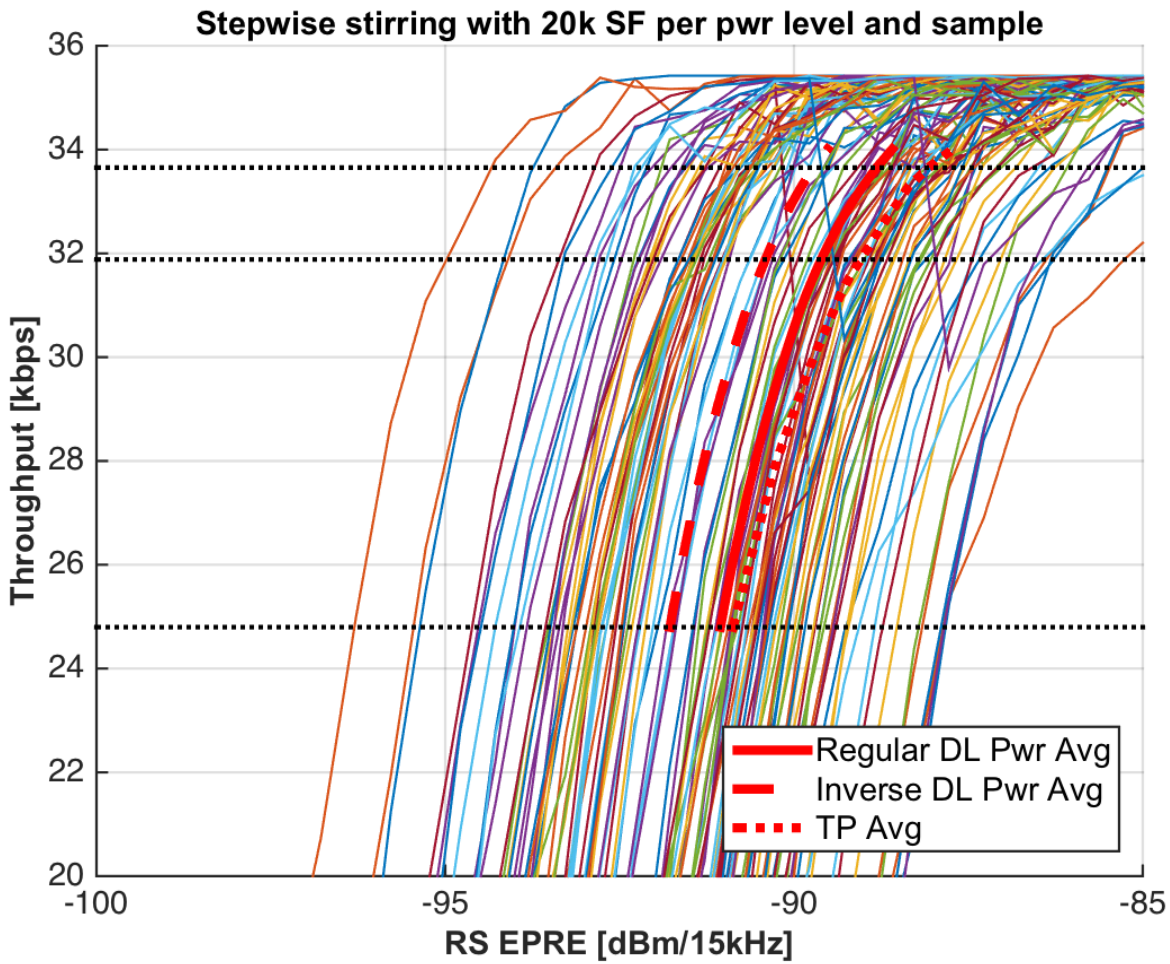
RC&CE


Continuous stirring with 20k SF per pwr level and sample
Throughput [kbps]
36
34
32
30
28
26
24
22
20
-100
-95
-90
-85
RS EPRE [dBm/15kHz]
Regular DL Pwr Avg
Inverse DL Pwr Avg
TP Avg

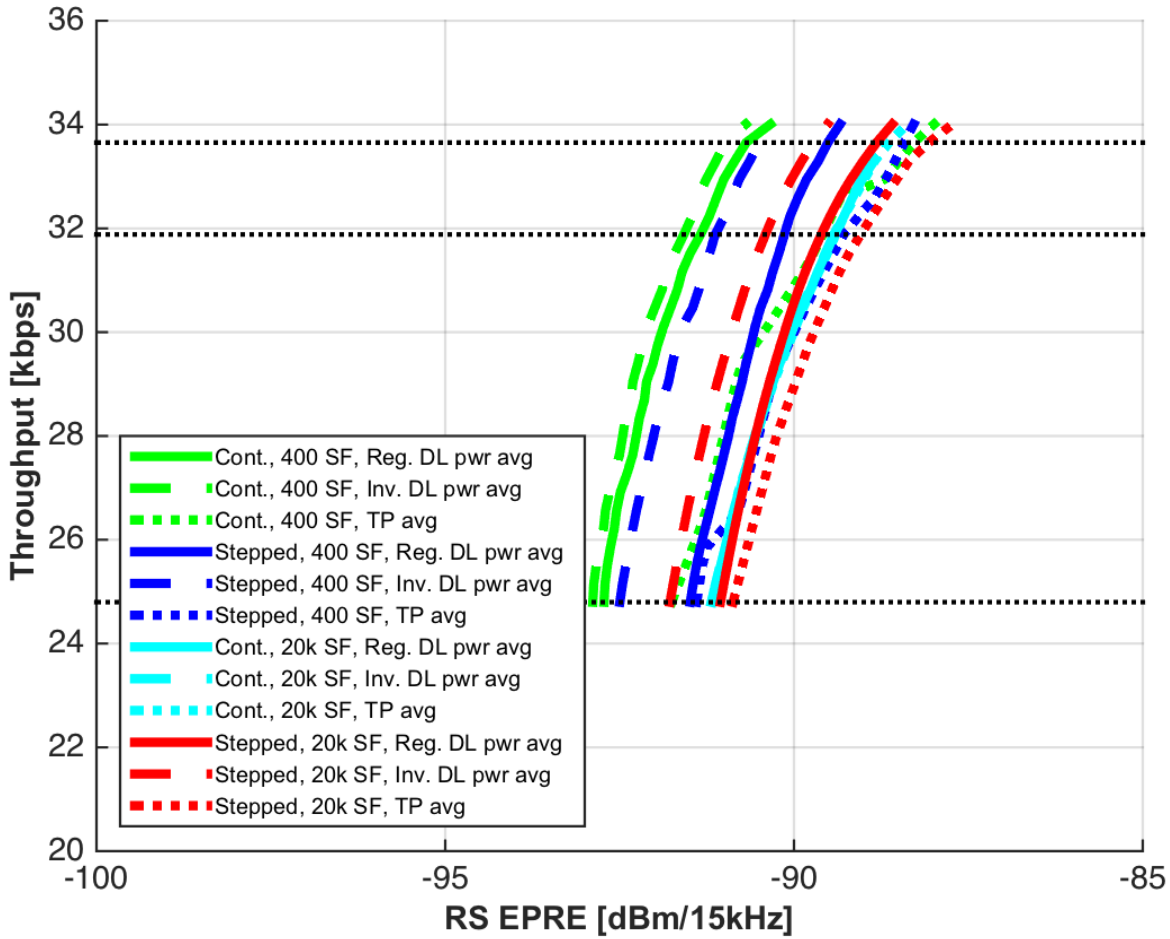
RC&CE


Stepwise stirring with 400 SF per pwr level and sample
Throughput [kbps]
36
34
32
30
28
26
24
22
20
-100
-95
-90
-85
RS EPRE [dBm/15kHz]
Regular DL Pwr Avg
Inverse DL Pwr Avg
TP Avg

RC&CE


Stepwise stirring with 20k SF per pwr level and sample
Throughput [kbps]
36
34
32
30
28
26
24
22
20
-100
-95
-90
-85
RS EPRE [dBm/15kHz]
Regular DL Pwr Avg
Inverse DL Pwr Avg
TP Avg

RC&CE: Comparing All Avg Approaches



RC&CE: TP RS EPRE

Band	DUT	RS EPRE [dBm/15 kHz] @ 70% TP_max																														
		RC +CE(UMa)															RC +CE(UMi)															
		Continuous - 400 SF			Continuous -20kSF			Stepped - 400 SF			Stepped -20kSF			Max DELTA			Continuous - 400 SF			Continuous -20kSF			Stepped - 400 SF			Stepped -20kSF			Max DELTA		
		Averaging Approach			Averaging Approach			Averaging Approach			Averaging Approach			Averaging Approach			Averaging Approach			Averaging Approach			Averaging Approach			Averaging Approach			Averaging Approach		
		regDL Pwr	inv DL Pwr	TP	regDL Pwr	inv DL Pwr	TP	regDL Pwr	inv DL Pwr	TP	regDL Pwr	inv DL Pwr	TP	regDL Pwr	inv DL Pwr	TP	regDL Pwr	inv DL Pwr	TP	regDL Pwr	inv DL Pwr	TP	regDL Pwr	inv DL Pwr	TP	regDL Pwr	inv DL Pwr	TP	regDL Pwr	inv DL Pwr	TP
FDD13	MOTO 1080	-92.7	-92.9	-91.8	-91.2	-91.2	-91.2	-91.5	-92.5	-91.4	-91.1	-91.8	-90.9	1.7	1.7	0.9	-97.9	-98.0	-97.1	-96.8	-96.8	-96.8	-96.5	-97.2	-96.3	-96.1	-96.7	-95.9	1.7	1.3	1.2
	MOTO 1096	-94.1	-94.2	-93.3	-92.9	-92.9	-92.9	-92.7	-93.6	-92.5	-92.8	-93.7	-92.7	1.3	1.3	0.8	-98.9	-99.0	-97.7	-98.1	-98.1	-98.1	-97.4	-98.2	-97.0	-97.6	-98.5	-97.4	1.5	0.9	1.1
	Sony Z3	-92.7	-92.8	-91.8	-91.5	-91.5	-91.5	-91.4	-92.2	-91.2	-90.8	-91.7	-90.6	1.9	1.3	1.2	-97.2	-97.3	-96.5	-95.9	-96.0	-95.9	-95.7	-96.3	-95.5	-95.9	-96.4	-95.7	1.5	1.4	1.0
FDD7	Samsung S4	-91.5	-91.6	-91.0	NaN	NaN	NaN	-91.1	-91.9	-91.0	NaN	NaN	NaN	0.3	0.3	0.1	-97.7	-97.8	-97.3	NaN	NaN	NaN	-97.6	-98.2	-97.5	NaN	NaN	NaN	0.1	0.4	0.1
	Samsung S6	-93.6	-93.7	-93.1	-92.8	-92.8	-92.8	-93.5	-94.3	-93.3	-93.3	-93.9	-93.1	0.7	1.5	0.4	-99.0	-99.1	-98.4	-98.4	-98.4	-98.4	-98.5	-99.1	-98.4	-98.8	-99.3	-98.7	0.6	0.9	0.3
	Sony Z3	-93.9	-94.0	-93.5	-93.9	-93.9	-93.9	-93.9	-94.6	-93.8	-94.1	-94.9	-93.9	0.2	1.0	0.4	-99.2	-99.3	-98.8	-99.3	-99.3	-99.3	-99.8	-100.3	-99.7	-99.3	-99.9	-99.2	0.6	1.0	0.9
TDD41	Lenovo A2860	-95.8	-95.9	-95.6	-95.1	-95.1	-95.1	-95.8	-96.4	-95.9	-95.0	-95.4	-95.2	0.8	1.3	0.8	-102.6	-102.7	-102.5	-102.2	-102.2	-102.2	-102.0	-102.4	-102.0	-70.8	-102.4	-102.1	31.8	0.5	0.4
	Lenovo A5860	-95.7	-95.8	-95.4	-95.3	-95.3	-95.3	-94.8	-95.4	-94.9	-94.2	-94.7	-94.3	1.5	1.0	1.1	-102.1	-102.1	-101.9	-101.9	-101.9	-101.9	-101.5	-101.9	-101.6	-101.4	-101.7	-101.5	0.6	0.4	0.5
	Samsung S5	-96.9	-97.0	-96.6	-96.6	-96.6	-96.6	-95.7	-96.7	-95.9	-96.2	-96.8	-96.3	1.2	0.4	0.8	-103.8	-103.9	-103.5	-103.4	-103.4	-103.4	-103.2	-103.6	-103.2	-103.0	-103.4	-103.0	0.8	0.5	0.5

Band	DUT	RS EPRE [dBm/15 kHz] @ 90% TP_max																														
		RC +CE(UMa)															RC +CE(UMi)															
		Continuous - 400 SF			Continuous -20kSF			Stepped - 400 SF			Stepped -20kSF			Max DELTA			Continuous - 400 SF			Continuous -20kSF			Stepped - 400 SF			Stepped -20kSF			Max DELTA		
		Averaging Approach			Averaging Approach			Averaging Approach			Averaging Approach			Averaging Approach			Averaging Approach			Averaging Approach			Averaging Approach			Averaging Approach			Averaging Approach		
		regDL Pwr	inv DL Pwr	TP	regDL Pwr	inv DL Pwr	TP	regDL Pwr	inv DL Pwr	TP	regDL Pwr	inv DL Pwr	TP	regDL Pwr	inv DL Pwr	TP	regDL Pwr	inv DL Pwr	TP	regDL Pwr	inv DL Pwr	TP	regDL Pwr	inv DL Pwr	TP	regDL Pwr	inv DL Pwr	TP	regDL Pwr	inv DL Pwr	TP
FDD13	MOTO 1080	-91.3	-91.6	-89.6	-89.4	-89.4	-89.4	-90.1	-91.1	-89.3	-89.6	-90.4	-89.0	1.9	2.1	0.5	-96.7	-96.9	-95.1	-95.2	-95.2	-95.2	-95.5	-96.2	-94.9	-95.1	-95.7	-94.4	1.7	1.7	0.8
	MOTO 1096	-92.9	-93.1	-91.4	-91.5	-91.5	-91.4	-91.5	-92.4	-90.9	-91.5	-92.5	-90.8	1.5	1.7	0.6	-97.7	-98.0	-96.1	-96.4	-96.4	-96.4	-96.4	-97.2	-95.6	-96.6	-97.4	-95.6	1.3	1.6	0.8
	Sony Z3	-91.0	-91.2	-89.6	-89.4	-89.4	-89.3	-89.8	-90.6	-89.2	-70.7	-90.2	-88.7	20.3	1.9	0.9	-96.2	-96.4	-94.6	-94.7	-94.7	-94.7	-94.7	-95.3	-93.9	-94.8	-95.4	-94.2	1.5	1.7	0.8
FDD7	Samsung S4	-89.9	-90.1	-89.2	NaN	NaN	NaN	-89.8	-90.6	-89.3	NaN	NaN	NaN	0.1	0.5	0.1	-96.3	-96.4	-95.7	NaN	NaN	NaN	-96.6	-97.1	-95.9	NaN	NaN	NaN	0.3	0.7	0.1
	Samsung S6	-92.1	-92.2	-91.4	-91.2	-91.2	-91.2	-92.3	-93.2	-91.7	-92.1	-92.7	-91.5	1.1	2.0	0.5	-97.5	-97.6	-96.9	-96.8	-96.8	-96.8	-97.5	-98.1	-96.8	-97.7	-98.2	-97.2	0.9	1.4	0.4
	Sony Z3	-92.5	-92.6	-91.8	-92.2	-92.2	-92.2	-92.7	-93.4	-92.0	-70.8	-93.7	-92.2	22.0	1.4	0.4	-97.7	-97.8	-97.3	-97.7	-97.7	-97.7	-98.7	-99.3	-98.1	-98.2	-98.8	-97.5	1.0	1.5	0.8
TDD41	Lenovo A2860	-94.2	-94.3	-93.9	-93.4	-93.4	-93.4	-94.5	-95.2	-94.0	-93.7	-94.1	-93.3	1.1	1.8	0.7	-101.0	-101.1	-100.4	-100.7	-100.7	-100.7	-100.9	-101.3	-100.5	-70.8	-101.3	-100.6	30.1	0.6	0.3
	Lenovo A5860	-94.0	-94.1	-93.7	-93.8	-93.8	-93.8	-93.5	-94.2	-93.0	-92.9	-93.5	-92.5	1.1	0.7	1.3	-100.5	-100.6	-100.1	-100.5	-100.5	-100.5	-100.4	-100.8	-100.2	-100.3	-100.6	-100.0	0.2	0.3	0.5
	Samsung S5	-94.8	-94.9	-94.5	-94.7	-94.7	-94.7	-93.8	-94.8	-93.5	-94.4	-95.0	-94.2	1.0	0.3	1.2	-102.3	-102.3	-101.9	-101.8	-101.8	-101.8	-102.0	-102.4	-101.7	-101.8	-102.2	-101.4	0.5	0.6	0.5

Band	DUT	RS EPRE [dBm/15 kHz] @ 95% TP_max																														
		RC +CE(UMa)															RC +CE(UMi)															
		Continuous - 400 SF			Continuous -20kSF			Stepped - 400 SF			Stepped -20kSF			Max DELTA			Continuous - 400 SF			Continuous -20kSF			Stepped - 400 SF			Stepped -20kSF			Max DELTA		
		Averaging Approach			Averaging Approach			Averaging Approach			Averaging Approach			Averaging Approach			Averaging Approach			Averaging Approach			Averaging Approach			Averaging Approach			Averaging Approach		
		regDL Pwr	inv DL Pwr	TP	regDL Pwr	inv DL Pwr	TP	regDL Pwr	inv DL Pwr	TP	regDL Pwr	inv DL Pwr	TP	regDL Pwr	inv DL Pwr	TP	regDL Pwr	inv DL Pwr	TP	regDL Pwr	inv DL Pwr	TP	regDL Pwr	inv DL Pwr	TP	regDL Pwr	inv DL Pwr	TP	regDL Pwr	inv DL Pwr	TP
FDD13	MOTO 1080	-90.7	-91.0	-88.3	-60.8	-88.3	-88.6	-89.5	-90.5	-88.4	-88.8	-89.7	-88.1	29.9	2.7	0.6	-96.1	-96.4	-94.3	-70.8	-94.4	-94.4	-95.1	-95.8	-93.8	-94.5	-95.2	-93.7	25.4	2.0	0.7
	MOTO 1096	-92.4	-92.7	-90.4	-70.7	-90.5	-90.5	-91.0	-91.9	-89.7	-90.8	-91.9	-89.8	21.6	2.2	0.8	-97.1	-97.4	-95.6	-58.0	-95.0	-95.6	-96.0	-96.7	-95.0	-96.1	-96.9	-94.9	39.1	2.5	0.8
	Sony Z3	-90.3	-90.6	-88.3	-70.7	-88.4	-88.4	-89.0	-89.8	-87.7	-70.7	-89.4	-87.5	19.5	2.2	1.0	-95.7	-95.9	-93.6	-70.8	-94.1	-94.1	-94.3	-94.9	-93.1	-94.3	-94.9	-93.4	24.9	1.8	1.0
FDD7	Samsung S4	-89.0	-89.1	-88.3	NaN	NaN	NaN	-89.2	-90.0	-88.5	NaN	NaN	NaN	0.2	0.8	0.1	-95.6	-95.7	-94.9	NaN	NaN	NaN	-96.1	-96.6	-95.2	NaN	NaN	NaN	0.5	0.9	0.4
	Samsung S6	-70.8	-91.5	-90.6	-90.4	-90.4	-90.4	-91.7	-92.7	-90.7	-91.5	-92.1	-90.8	21.0	2.3	0.4	-64.8	-97.0	-96.3	-63.8	-95.9	-96.0	-97.0	-97.6	-96.1	-97.2	-97.7	-96.4	33.4	1.8	0.4
	Sony Z3	-91.7	-91.8	-91.1	-91.4	-91.4	-91.4	-92.1	-92.9	-91.4	-67.8	-93.1	-91.4	24.3	1.6	0.3	-97.2	-97.3	-96.6	-96.9	-97.0	-96.9	-98.3	-98.8	-97.3	-97.7	-98.3	-96.7	1.3	1.8	0.7
TDD41	Lenovo A2860	-93.6	-93.6	-93.1	-67.8	-92.5	-92.5	-93.9	-94.6	-93.1	-93.1	-93.5	-92.6	26.1	2.1	0.6	-100.2	-100.3	-99.8	-99.9	-99.9	-99.9	-100.5	-100.9	-99.9	-70.8	-100.8	-99.9	29.7	1.0	0.1
	Lenovo A5860	-93.4	-93.5	-92.8	-93.0	-93.0	-93.0	-92.9	-93.6	-92.1	-92.4	-92.9	-91.7	1.0	0.7	1.2	-99.8	-99.9	-99.4	-99.6	-99.6	-99.5	-100.0	-100.4	-99.3	-99.9	-100.1	-99.3	0.4	0.8	0.3
	Samsung S5	-94.0	-94.1	-93.6	-93.6	-93.6	-93.6	-92.9	-94.1	-92.3	-93.6	-94.3	-93.1	1.1	0.7	1.3	-101.6	-101.7	-101.1	-101.0	-101.0	-101.0	-101.5	-101.9	-100.9	-101.2	-101.6	-100.6	0.6	0.8	0.4

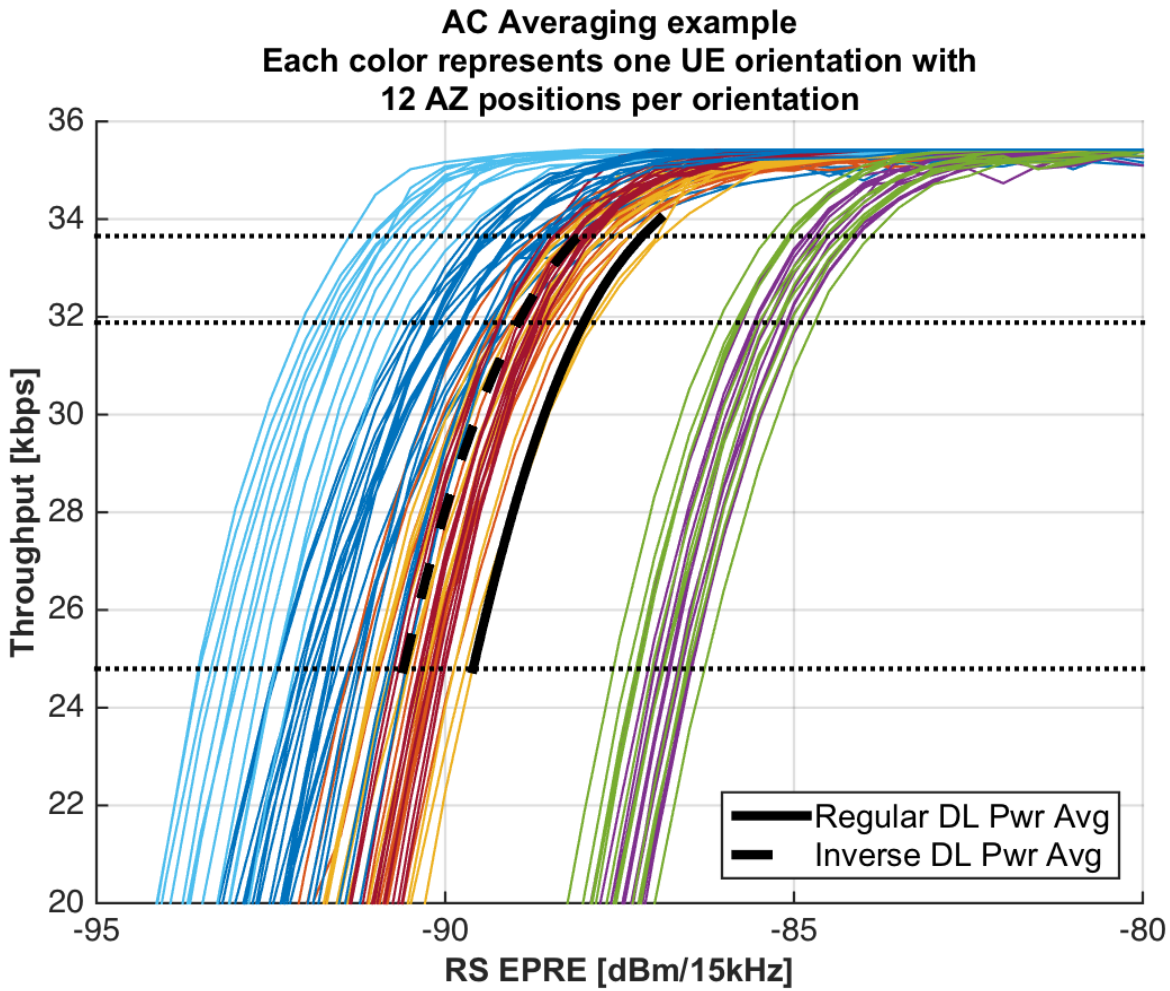
RC&CE: Review

- TP curves taken with 400 SF per power level and stirring mode have large TP jumps while the TP curves taken with 20k SF are much more continuous
- Generally, DL power average approaches result in larger RS EPRE differences (with respect to # of SF and stirring modes) than TP average approach
- The difference between continuous 400 SF and 20k SF RS EPRE results is generally greater than the difference between stepped 400 SF and 20k SF RS EPRE results

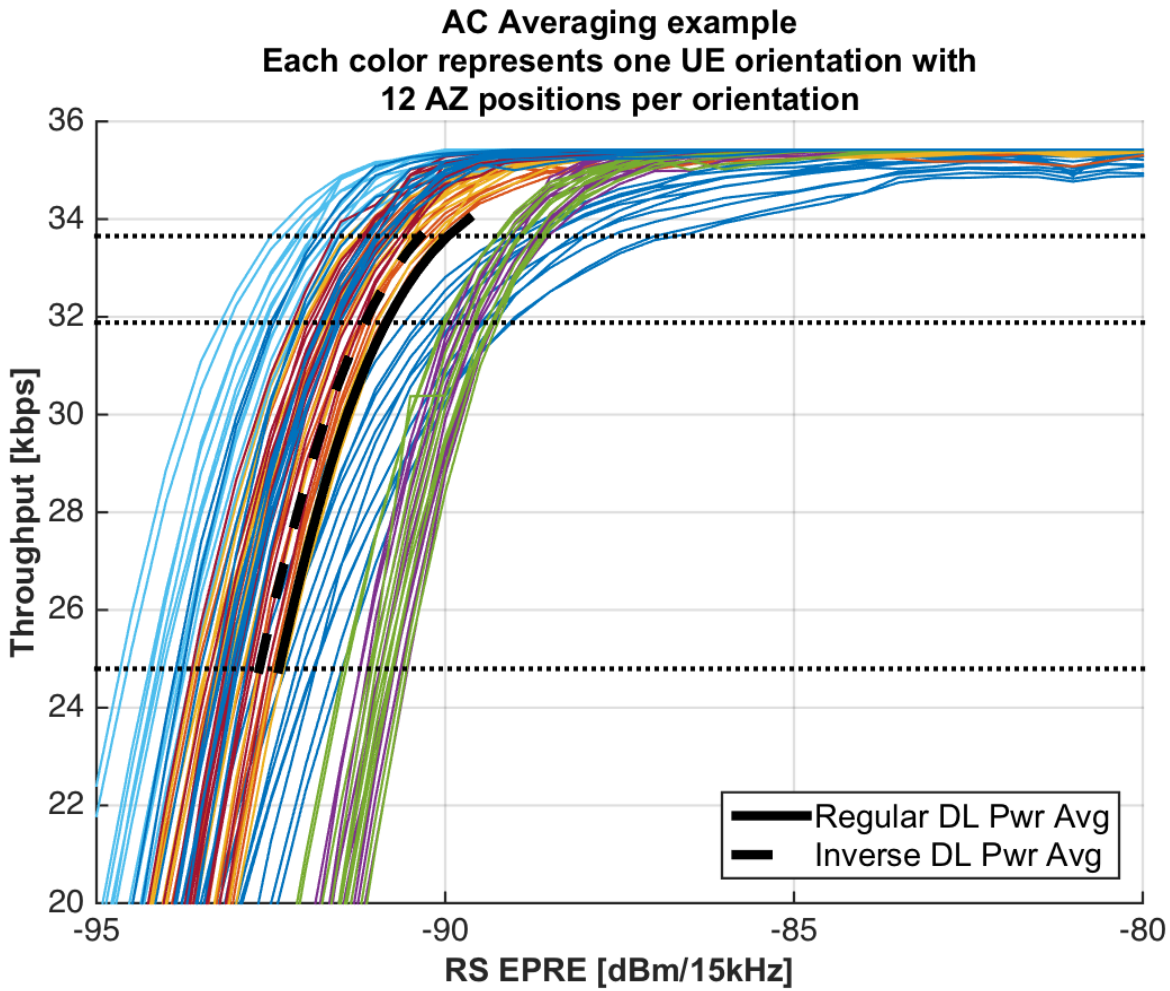
AC Examples

- In the following slides, averaging examples for the AC results are presented
  - Band: FDD13
  - Channel Model: UMa

MPAC: Motorola 1080



MPAC: Motorola 1096

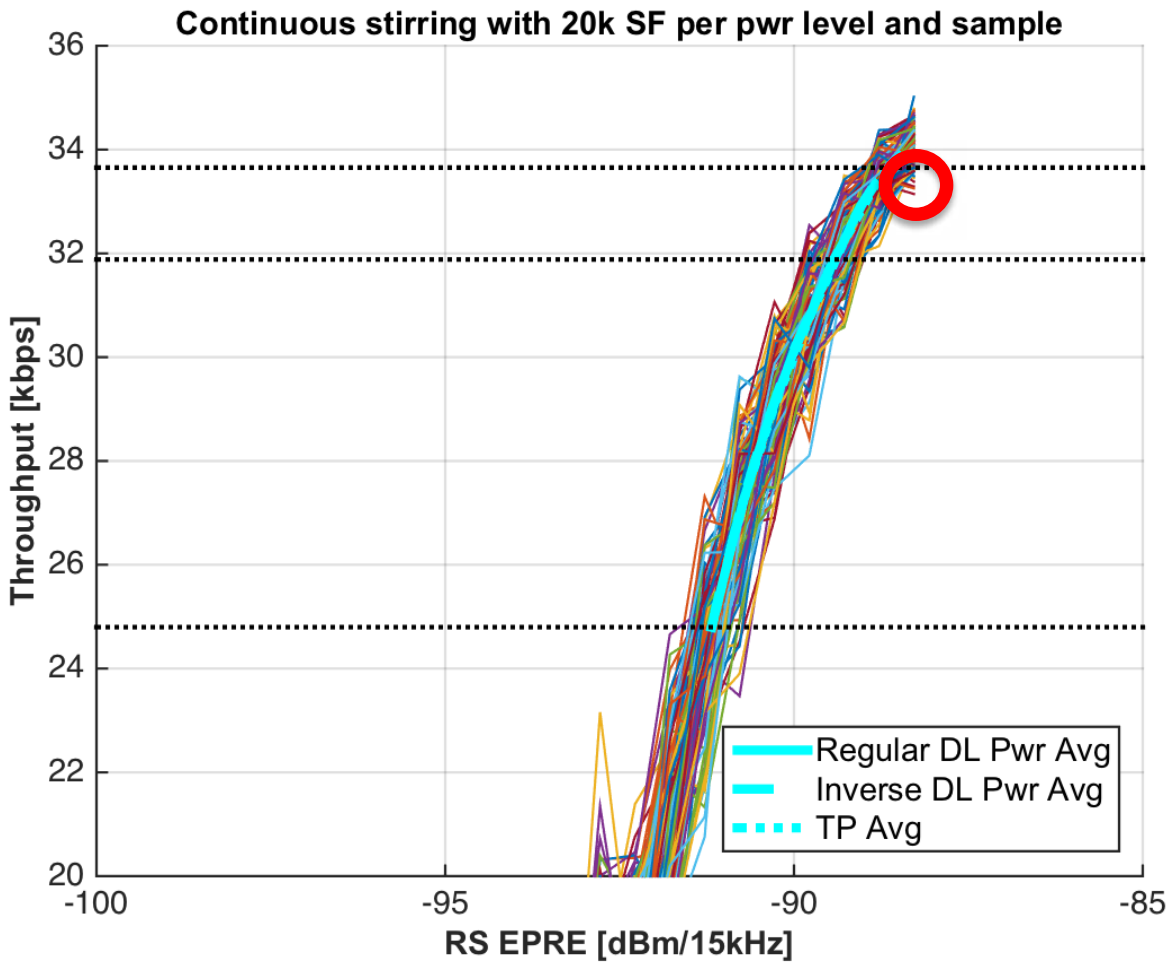


DL Power Avg: Outage TP Level Not Reached

- Some UEs don’t achieve outage TP level
- RTS, MPAC, and RC&CE demonstrated cases where outage TP level could not be reached

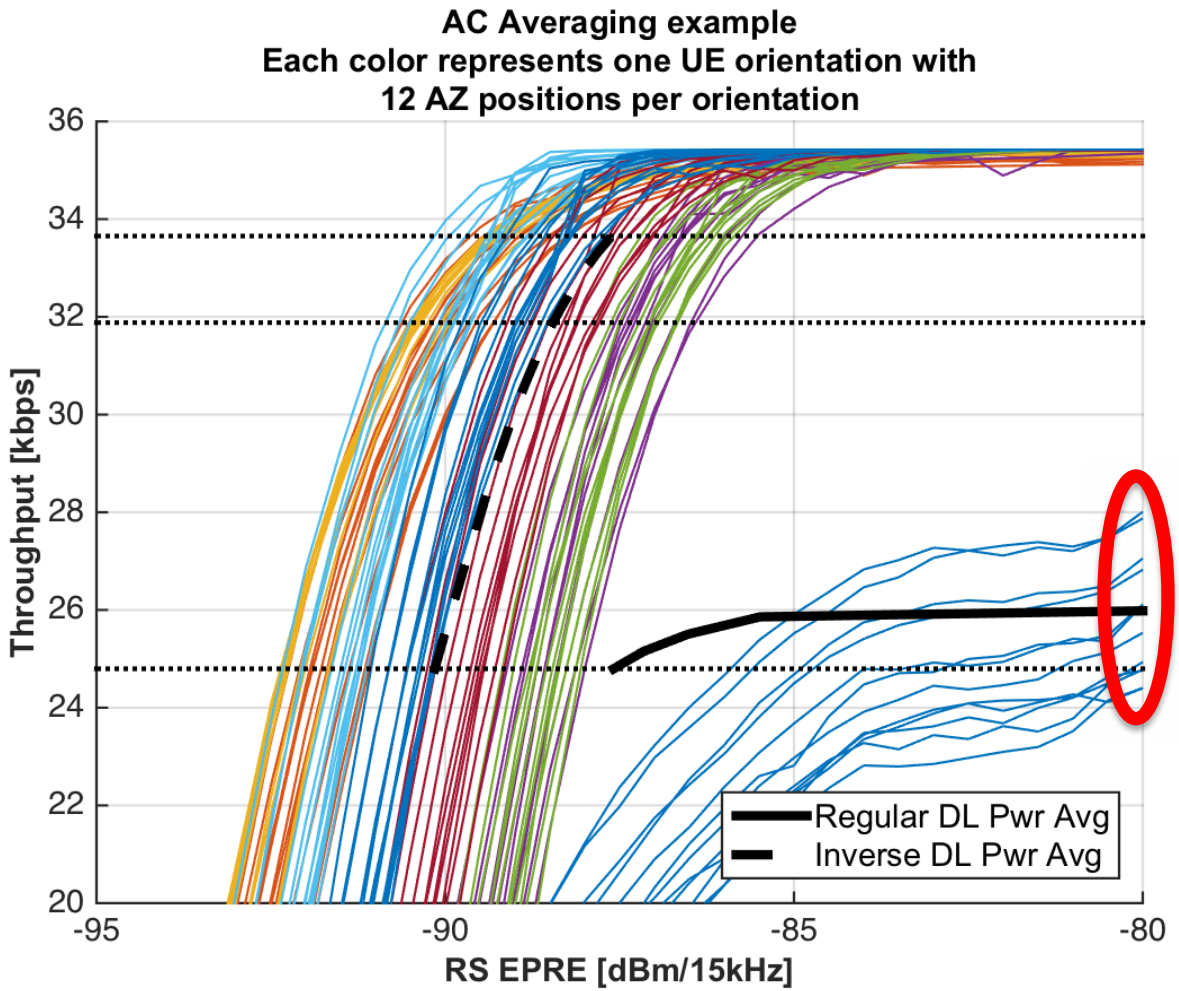
Outage TP Level Not Reached: RC&CE

(Motorola 1080, FDD13)



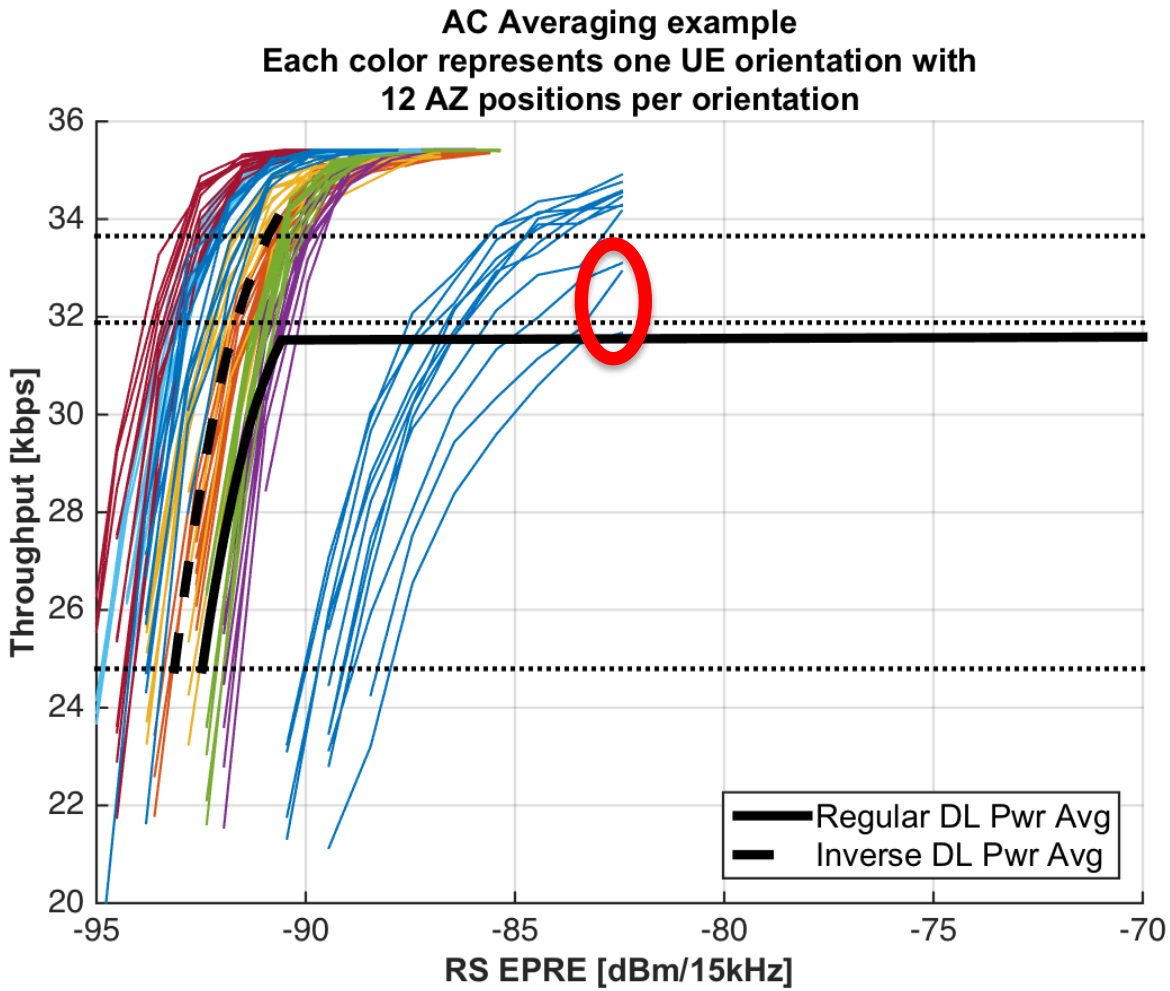
Outage TP Level Not Reached: MPAC

(Sony Z3, FDD13)



Outage TP Level Not Reached: RTS

(Motorola 1096, FDD13)



DL Power Avg: Substitute RS EPRE

- The curves that do not reach the outage TP level require a ‘substitute RS EPRE’ at said outage TP or not be taken into account in the averaging
  - The poor performance of the UE will <u>not</u> be taken into account if the curve(s) are ignored
  - The poor performance of the UE will be taken into account with a ‘substitute RS EPRE’

DL Power Avg: Substitute RS EPRE

- Example: RTS results of Motorola 1096 with one curve that did not reach 90% outage TP
  - Substitute RS EPRE should be relatively high DL power level

Ch. Model	DUT Orientation	RS EPRE [dBm/15 kHz] @ 90% TP_max													
		AC (MPAC or RTS)													
		0	30	60	90	120	150	180	210	240	270	300	330	INV. AVG	Reg. AVG
UMa	1. Portrait, no tilt	-83.3	-60.0	-84.6	-86.3	-86.9	-87.5	-87.2	-86.2	-86.2	-86.6	-86.7	-85.6	-85.9	-70.7
	2. Portrait, 45° tilt down	-91.3	-91.3	-91.2	-91.3	-91.4	-91.7	-91.3	-91.3	-91.6	-91.7	-91.8	-91.6	-91.5	-91.5
	3. Portrait, 45° tilt up	-92.1	-92.0	-92.3	-92.4	-92.4	-92.3	-91.9	-91.3	-91.1	-91.2	-91.8	-92.2	-91.9	-91.9
	4. Face up	-90.8	-90.6	-91.0	-91.0	-90.9	-90.6	-90.5	-90.5	-90.1	-90.3	-90.5	-90.5	-90.6	-90.6
	5. Face down	-90.9	-91.0	-91.0	-90.7	-90.7	-90.7	-90.9	-91.2	-91.1	-91.1	-91.2	-91.2	-91.0	-91.0
	6. Landscape, no tilt	-92.8	-92.8	-92.9	-93.1	-93.2	-93.4	-93.3	-93.0	-93.0	-93.1	-93.0	-92.9	-93.0	-93.0
	7. Landscape, 45° tilt down	-92.8	-92.8	-93.0	-93.1	-93.2	-93.4	-93.7	-93.9	-93.6	-93.5	-93.3	-93.1	-93.3	-93.3
	8. Landscape, 45° tilt up	-93.1	-92.9	-92.8	-92.9	-92.4	-92.2	-92.0	-91.9	-92.4	-93.0	-92.5	-92.8	-92.6	-92.6
												8 Orientations		**-91.7**	**-79.5**

Test that did not achieve target TP value

DL Power Avg: Substitute RS EPRE

- Substitute RS EPRE has
  - little to no effect on the inverse DL Pwr Avg approach
  - Very large effect on the regular DL Pwr Avg approach

Effect of substituted RS EPRE (when target TP is not reached) on MIMO Average Radiated Sensitivity				
Substituted RS EPRE [dBm/15 kHz]	Inverse Avg		Regular Average	
	Single Orientation (#1)	All 8 Orientations	Single Orientation (#1)	All 8 Orientations
-50	-85.9	-91.7	-60.8	-69.8
-60	-85.9	-91.7	-70.7	-79.5
-70	-85.9	-91.7	-79.7	-87.2
-80	-86	-91.7	-85	-90.2

DL Power Avg: Outage TP Level Not Reached

- Alternatives to account for poor UE behavior
  - Do not include curves that were not able to reach outage TP into averaging but report number of tests/curves that did not reach outage TP level
  - Do not include curves that were not able to reach outage TP into averaging but offset MIMO average sensitivity by fixed value per test/curve that did not reach outage TP level

Recommended Test Case Definitions

- RC&CE:
  - Use more than 400 SF per power level and mode
  - Use step-wise stirring only
  - Use the same averaging approach as AC methods
- Harmonized Methods:
  - Use regular DL power averaging approach (to match the approach used in CTIA)
  - Use 70% outage TP level (to avoid having to substitute RS EPRE until suitable approach can be identified)