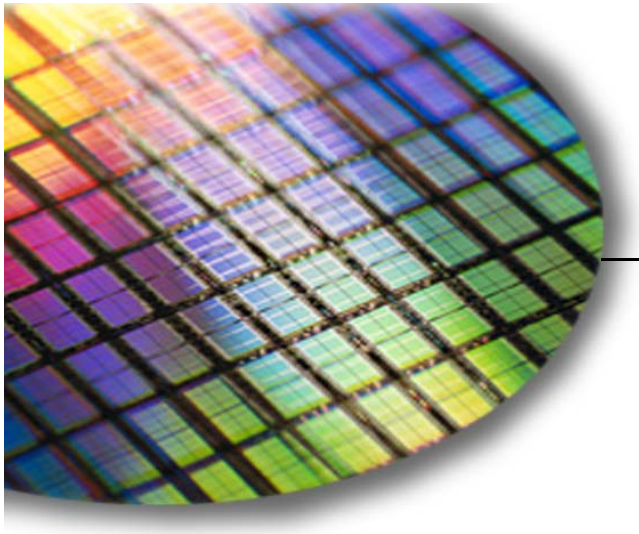

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SRD Operation in the 868 MHz Band with Adjacent LTE

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Analog Devices

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Agenda

- Introduction
- Potential interference - LTE spectrum profile in relation to the SRD Blocking and Co-channel Rejection parameters.
- Measurement Plan and Test set up
- Results
- Conclusions
- Questions

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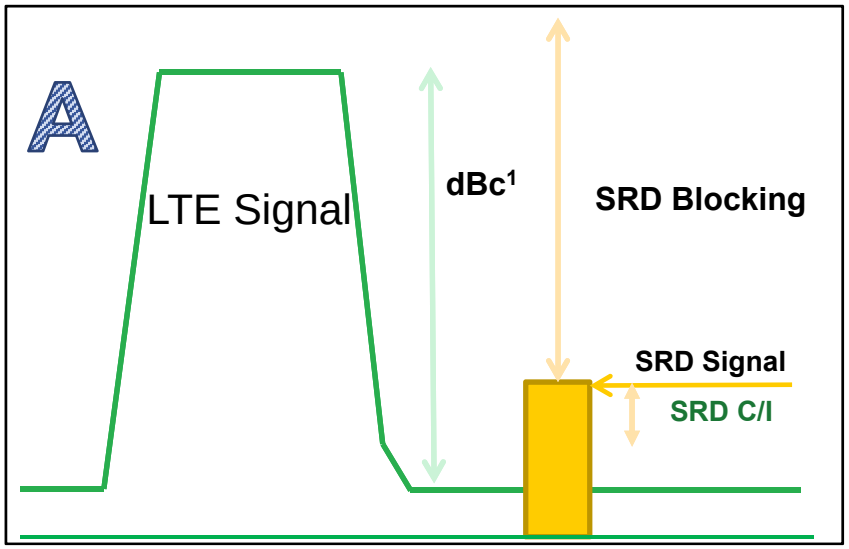
Introduction

- **Short Range Devices (SRDs) operating in the 863MHz to 870MHz Band have got new neighbours. The User Equipment (UE) uplink of LTE band 20 is allocated the frequency band 832MHz to 862MHz. The upper end of this band is close to the SRD band 863MHz to 870MHz.**

- **Various reports on the probability of interference between SRD devices have been published. For example ECC Report 207 from SE24 found a probability range of the order of <5% to >35% depending on the SRD parameters such as Blocking and Co-channel rejection as well as LTE spectrum profile used.**

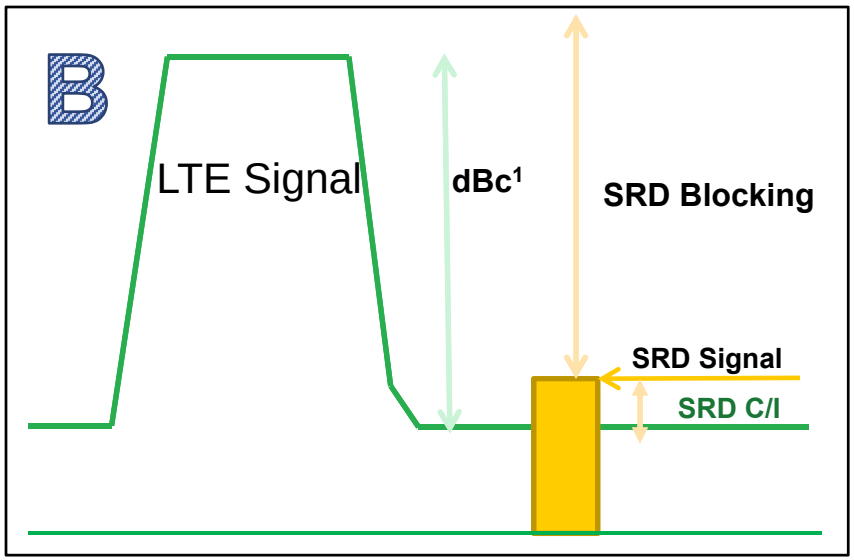
- **This presentation looks at interference conditions focusing on the relationship between the LTE spectrum profile and the SRD Blocking and Co-channel rejection parameters.**

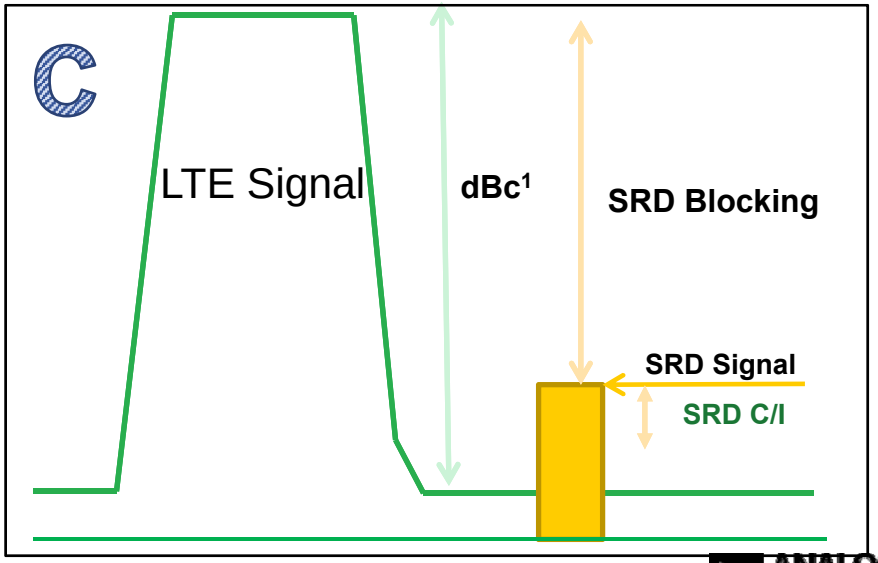
Relationship between LTE spectrum profile and SRD Blocking and Co-channel Rejection



In diagram **A** the LTE signal is below the SRD Blocking level and the OoB are below the SRD co-channel rejection level=> operation successful.

As the LTE signal increases relative to the SRD signal if the delta between the LTE signal and OoB is less than the delta between the SRD Blocking and co-channel rejection then the first failure mechanism will be related to co-channel interference, case **B**. If the inverse is true, as shown in **C** then the first mechanism will be associated with blocking.





[1] dBc here refers to the level of the LTE OoB in the SRD receiver Bandwidth relative to the LTE wanted signal.

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A perspective on SRD Blocking

Specifications:

Standard	Offset frequency →	1 MHz	2 MHz	5 MHz	10 MHz	
EN 300 220 v2.4.1	Category 1		84 dB -A		84 dB-A	Note 1
	Category 2		35 dB-A		60 dB-A	Note 1
	Category 3		24 dB-A		44 dB-A	Note 1
EN 54 25:2008		40 dB	45 dB	60 dB	65dB	

Note 1: A = 10 log (BW_{kHz}/ 16kHz) BW is the receiver bandwidth.

Example of measured data with SRD transceiver at 100kbps BER 10-3, constant envelope interferer

Measured	Offset frequency →	1 MHz	2 MHz	5 MHz	10 MHz
ADF7023		58dB	62.5 dB	67 dB	69dB

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A perspective on the LTE spectrum profile

3GPP TS 36.101 V9.21.0 Specifications

Spectrum emission limit (dBm)/ Channel bandwidth							
Δf_{OOB} (MHz)	1.4 MHz	3.0 MHz	5 MHz	10 MHz	15 MHz	20 MHz	Measurement bandwidth
± 0-1	-10	-13	-15	-18	-20	-21	30 kHz
± 1-2.5	-10	-10	-10	-10	-10	-10	1 MHz
± 2.5-2.8	-25	-10	-10	-10	-10	-10	1 MHz
± 2.8-5		-10	-10	-10	-10	-10	1 MHz
± 5-6		-25	-13	-13	-13	-13	1 MHz
± 6-10			-25	-13	-13	-13	1 MHz
± 10-15				-25	-13	-13	1 MHz
± 15-20					-25	-13	1 MHz
± 20-25						-25	1 MHz

Table 1 General Spectrum emission mask limits

- Spurious Domain limit: -36dBm in 100kHz Bandwidth
- UE Max transmit power 23dBm

Measurement Plan

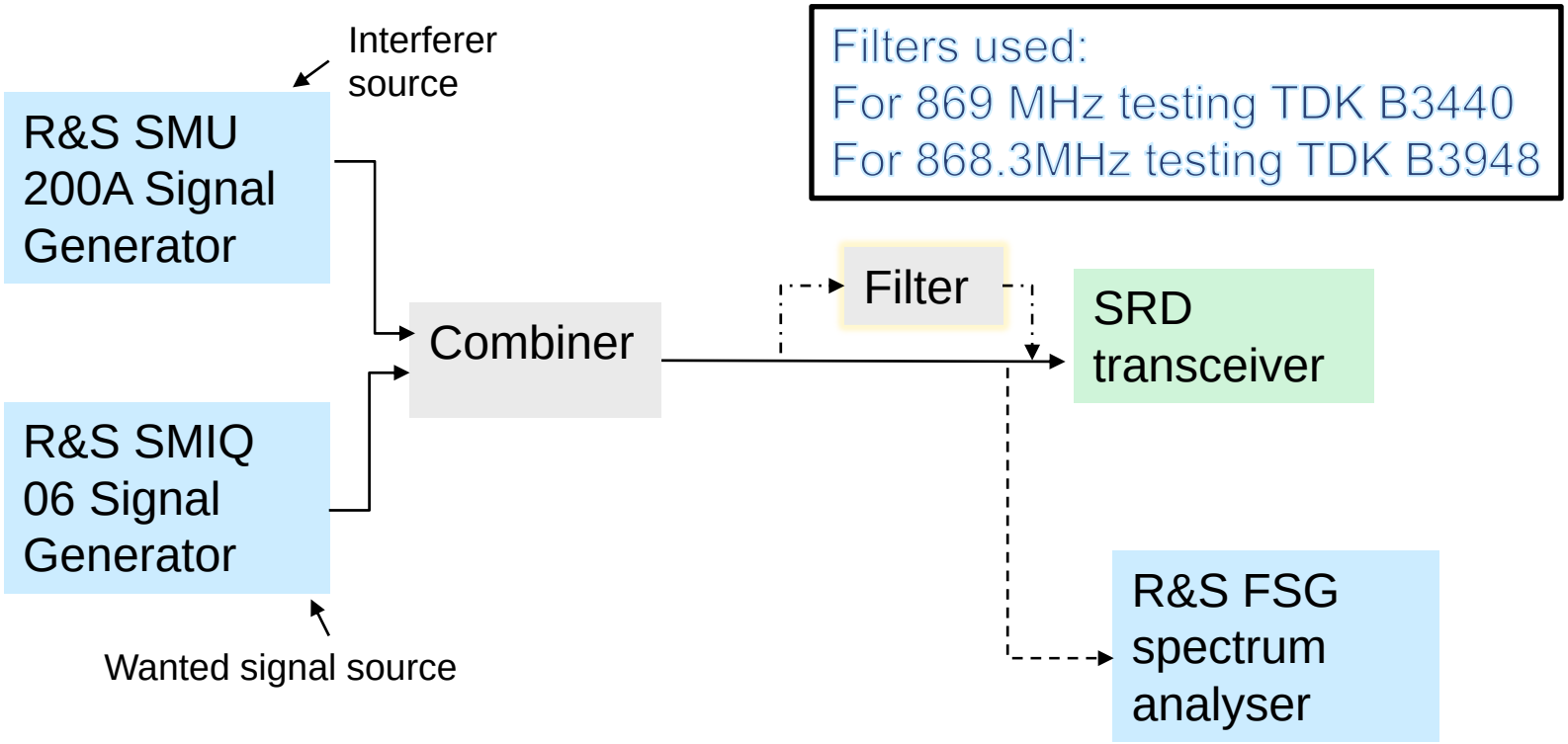
- **Test with different LTE spectrum profiles which include cases B and C mentioned earlier. Include a GFSK interferer for reference. Signal generators used for the wanted and interfering signals but with the two LTE 10 MHz signals being playback of recorded signals. OoB emissions from a signal generator may be expected to be lower than a real use case but the objective is to test with different limiting factors on performance. Further details of spectral profiles used on later slide.**

- **SRD configuration of the ADF7023 transceiver used for SRD receiver testing:**
  - **GFSK, 100kbps, 35kHz deviation**
  - **Receiver Bandwidth 150kHz**

- **Test criteria: What interferer level results in a BER 10-3 on the SRD receiver with an SRD wanted signal level = -94 dBm. This corresponds with the wanted signal level for the above configuration for Blocking tests in EN 300 220.**

- **Test with and without a SAW. The pass band of the SAWs were 868 MHz to 870 MHz/ 868 MHz to 869.2 MHz. Given this pass band, to capture data at reduced offsets between the LTE and SRD signals 2 data points were included with the LTE signal in the SRD Band. This was to replicate a condition which may exist at the lower end of this SRD band.**

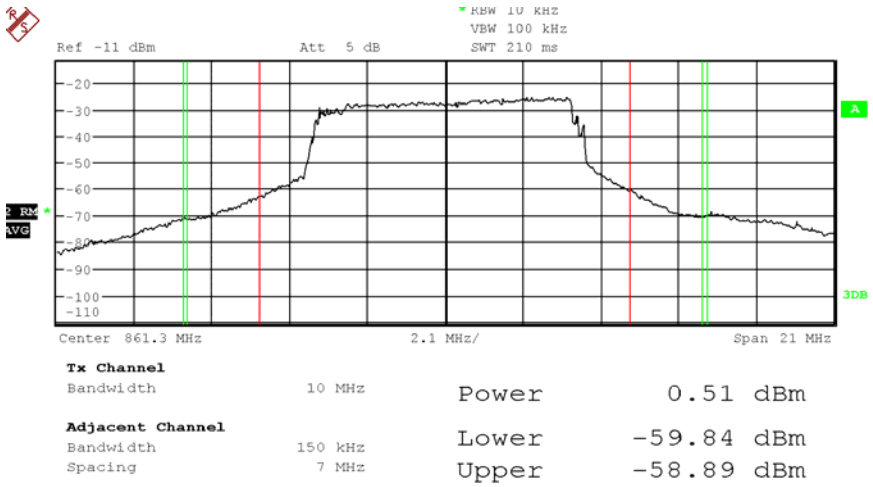
Test Set Up



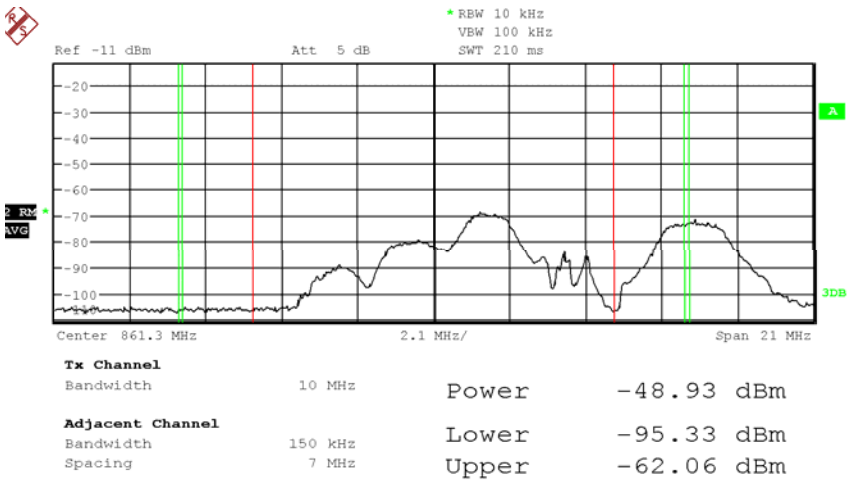
Measurements were conducted. The signal levels and OoB emissions were checked using a spectrum analyser at the SMA connector which connected to the SRD receiver.

Test signals

SRD RX Frequency	Interferer TX Frequency	Interferer	LTE OoB in SRD Receiver BW	OoB Margin to specification
869 MHz	857 MHz	LTE 10 MHz, 50 rb i)	-69 dBc	24.8 dB
869 MHz	857 MHz	LTE 10 MHz, 50 rb ii)	-59.4 dBc	15.2 dB
869 MHz	857 MHz	LTE 3 MHz, 15 rb	-90.4 dBc	33.1 dB
869 MHz	860 MHz	LTE 3 MHz, 15 rb	-90 dBc	32.7 dB
869 MHz	854 MHz	LTE 3 MHz, 15 rb	-90.3 dBc	33.0 dB
869 MHz	857 MHz	GFSK	-93.6 dBc	___
868.3 MHz	861.3 MHz	10 MHz, 50 rb i)	-59,4 dBc	18.2 dB
868.3 MHz	864 MHz	3 MHz, 15 rb	-87 dBc	45.8
868.3 MHz	861.3 MHz	GFSK	-93.5 dBc	____



10 MHz, 50 rb i) without filter



10 MHz, 50 rb i) with filter

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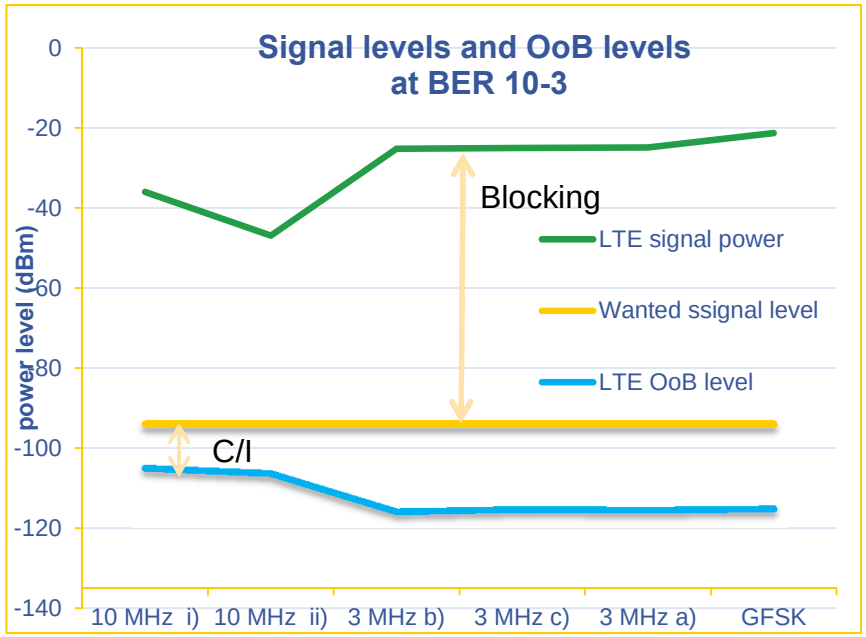
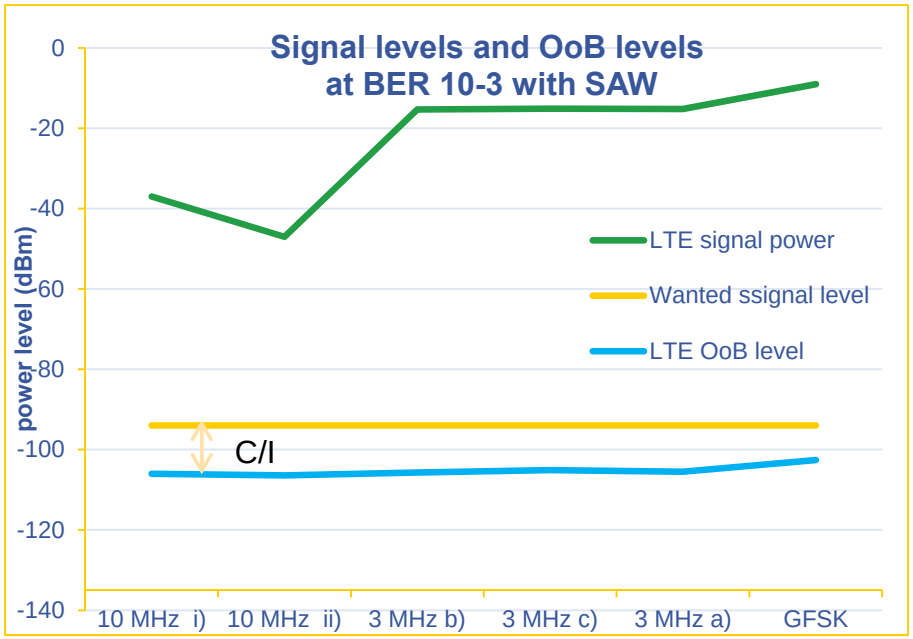
Results for different spectral profiles





- The interferer level at which the 10MHz LTE cases give rise to 10-3 BER is the same with and without the SAW. The limiting factor is C/I.
- In the other cases, where Blocking is the limiting mechanism, higher signal levels are tolerated with a SAW.
- Both Blocking and C/I for LTE signal appear less robust than with GFSK interferer. LTE rms power used but this is not constant envelope modulation so the peak power may be expected to impact the Blocking performance.

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Results at different offset frequencies – no SAW

Interferer signal	Interferer Centre Frequency	Interferer channel edge Frequency	Wanted signal Frequency	Interferer level at BER 10-3
LTE 10 MHz i)	857 MHz	862 MHz	869 MHz	-36 dBm
LTE 10 MHz i)	861.3 MHz	866.3 MHz	868.3 MHz	-46.9 dBm
LTE 3MHz	857 MHz	858.5 MHz	869 MHz	-25.2 dBm
LTE 3MHz	864.3 MHz	865.8MHz	868.3 MHz	-26.5 dBm
GFSK	857 MHz	857.1 MHz	869 MHz	-21.3 dBm
GFSK	864.3 MHz	864.4 MHz	868.3 MHz	-22.2 dBm

Performance at closer offset frequencies around 1dB lower where performance was Blocking limited. Interferer level 10.9dB lower for closer offset frequency where Co-channel is the limiting factor.

Results at different offset frequencies – with SAW

Interferer signal	Interferer Centre Frequency	Interferer channel edge Frequency	Wanted signal Frequency	Interferer level at BER 10-3
LTE 10 MHz i)	857 MHz	862 MHz	869 MHz	-37 dBm
LTE 10 MHz i)	861.3 MHz	866.3 MHz	868.3 MHz	-46 dBm
LTE 3MHz	857 MHz	858.5 MHz	869 MHz	-15.32 dBm
LTE 3MHz	864.3 MHz	865.8MHz	868.3 MHz	-14.9 dBm
GFSK	857 MHz	857.1 MHz	869 MHz	-9 dBm
GFSK	864.3 MHz	864.4 MHz	868.3 MHz	-8.8 dBm

Similar performance at different offset frequencies where performance was Blocking limit. Interferer level 9dB lower for closer offset frequency where Co-channel is the limiting factor.

Commentary on Results

- **Selecting the profile of the interferer enables control of testing of the different mechanisms separately.**
- **Most resilience data available for SRD transceivers is based on CW or the same modulation as the wanted signal.**
  - **To be able to relate this performance data to what it would mean with an LTE interferer would therefore be useful.**
- **The Blocking profile between 2 MHz and 10 MHz offset does not follow a straight line, with a much lower change between 5 MHz and 10 MHz offset for example.**
- **While this testing was carried out with a fixed wanted signal future testing with a real LTE signal over different power levels would be of value, particularly with the advent of envelope tracking.**

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Conclusion

- By comparing the difference between the LTE signal level and the associated OoB emissions which fall in-band in the victim receiver with the delta between the SRD Blocking level and Co-channel rejection level, the limiting factor for interference may be identified. When the LTE difference is smaller than the SRD delta then the OoB is the limiting factor. When the SRD parameter delta is smaller then Blocking is the limiting factor.

- Consideration needs to be given to the fact that LTE is not constant envelope in relating the blocking performance of constant envelope interferers to blocking with an LTE interferer.

- Further investigation of co-channel rejection performance with an LTE interferer would also be beneficial.

QUESTIONS?

Thank you.