White Paper

850 MHz & 900 MHz Co-Existence

850 MHz Out-Of-Band Emissions Problem

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1. Introduction and Background

Network administrators and engineers around the globe acknowledge that 850 MHz and 900 MHz spectrums generate interference problems when deployed in the same geographic area.

This interference occurs in two ways:

1.1 Receiver blocking and resultant intermodulation interference, caused by high power levels from the 850 MHz downlink (DL) transmit hitting the front end of the 900 MHz BTS receiver.

1.2 Out-of-band emissions from 850 MHz BTS entering the 900 MHz uplink (UL) band.

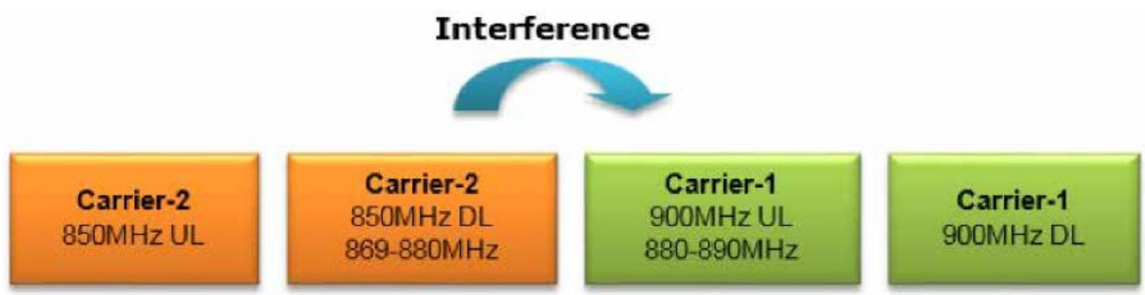

Figure 1: The Problem

The interference caused by out-of-band emissions from an 850 MHz BTS can only be fixed by fitting a filter to the 850 MHz transmitter (Carrier-2 in this paper) to sufficiently reduce any out-of-band transmissions.

Addressing the receiver blocking problem requires a filter in the 900 MHz site (Carrier-1 in this paper). For more information about this please refer to the Kaelus paper "Receiver Blocking Problem."

This paper incorporates a link budget methodology to estimate the additional attenuation required to address the 850 MHz out-of-band emission issue.

2. Assumptions

A typical scenario with below definitions is assumed. In this scenario, both carriers deploy UMTS technology.

The calculation covers a sector in Carrier-1 (receiver) directed toward the null point of a Carrier-2 BTS, as illustrated in Figure 2. The application includes a dual-polarised (X-Pol) antenna for 800-960 MHz frequency band at both BTS sites. This antenna has 65 horizontal and 7.5 degree vertical beamwidth, with gain of 17.5 dBi and height of 2.8 m. It is also assumed that the antennas are installed at the same height and have a clear line of sight, for the sake of simplicity.

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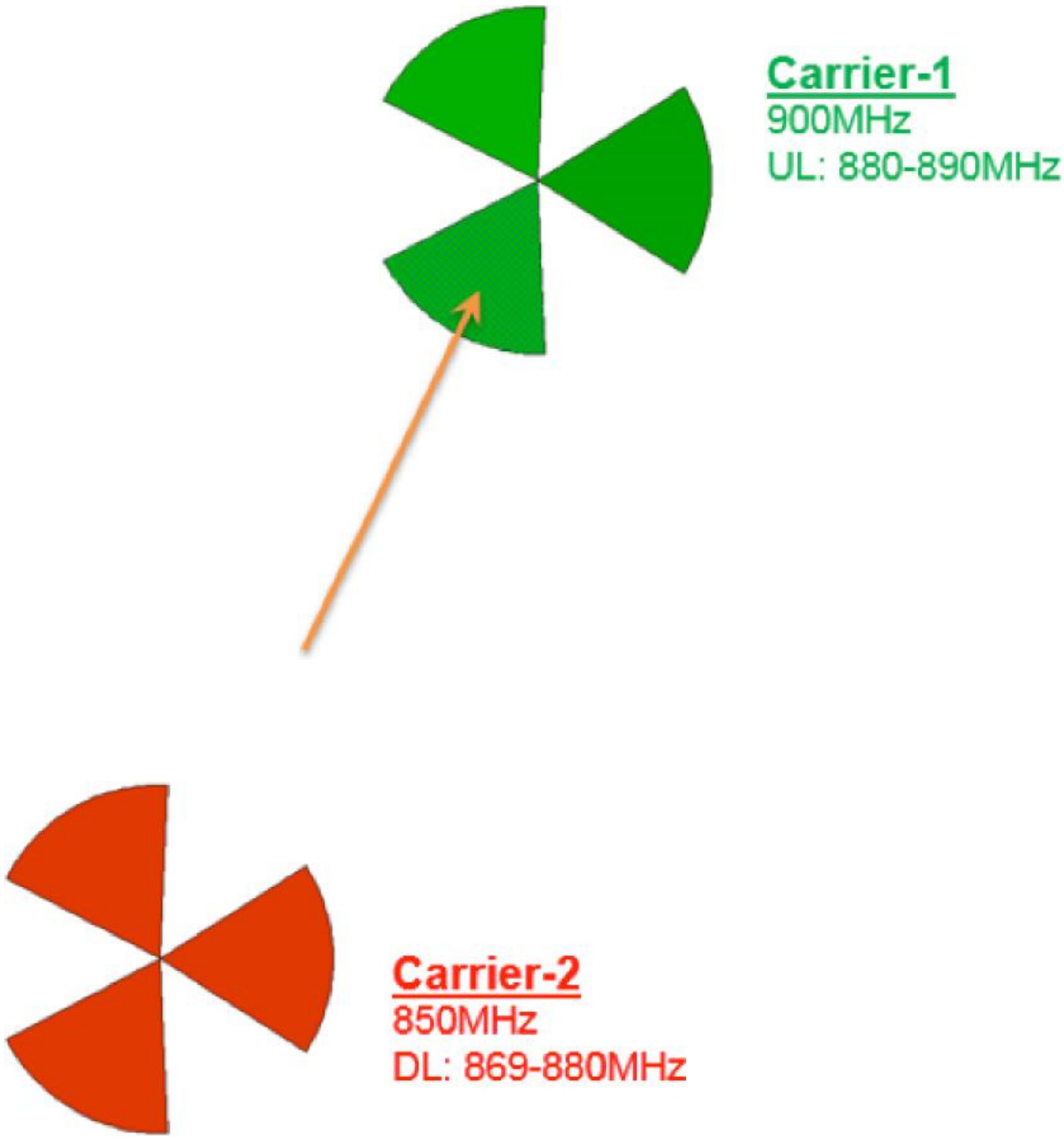

Figure 2: Scenario Diagram

The distance between above BTS sites is assumed to be 200 m. In addition to this scenario, the two carriers may share the tower and co-locate their antennas. Estimations for the co-location case and different distances between sites are also provided in this paper.

Figures 3 and 4 detail the antenna propagation models for the transmitter site (i.e. Carrier-2 BTS) and the receiver site (i.e. Carrier-1 BTS). The pattern for the transmitter is different from the receiver as all sectors transmit simultaneously, and the crossovers at null point “fill” with transmission.

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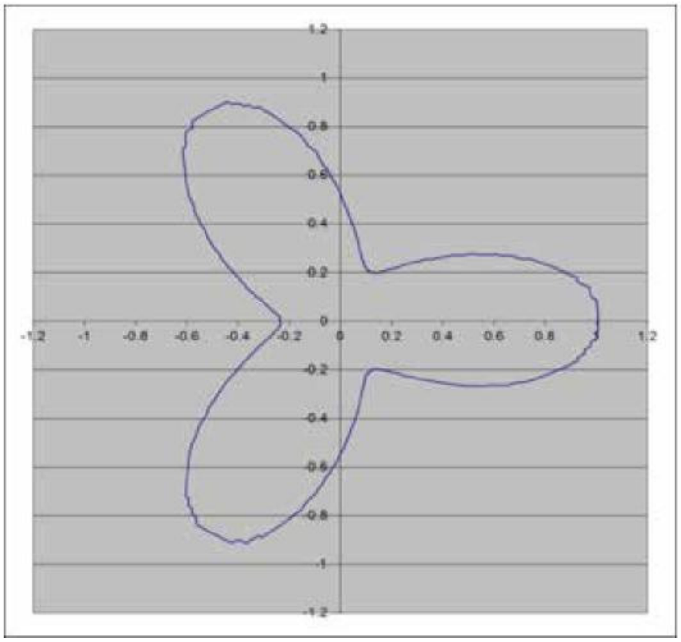

Figure 3: Transmitter Site Pattern

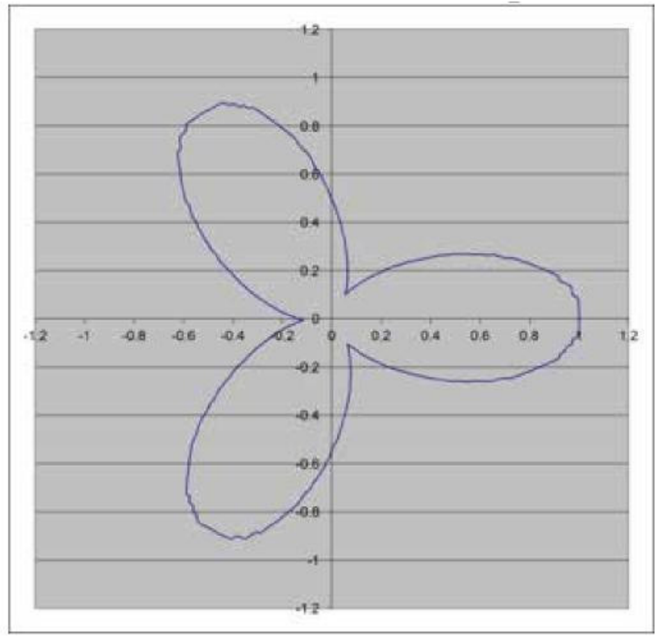

Figure 4: Receiver Site Pattern

The rest of the assumptions are indicated in the following table:

Table 1

	Quantity	Value	Comments
Transmitter Side (Carrier - 2 BTS):			
(A)	Output Power	46 dBm	
(B)	Feeder Loss	2 dB	
(C)	Peak Antenna Gain	17.5 dBi	
(D)	Antenna Null Toward Receiver	6.5 dB	According to the Assumed Pattern and Bearing
(E)	Antenna Gain Loss Due to Down Tilt	1 dB	2 Degree Down Tilt Assumed
(F)	Effective Antenna Gain	10 dBi	(C)-(D)-(E)
Receiver Side (Carrier - 1 BTS):			
(G)	Feeder Loss	2 dB	
(H)	Peak Antenna Gain	17.5 dBi	
(I)	Antenna Null Toward Transmitter	0 dB	According to the Assumed Pattern and Bearing
(K)	Antenna Gain Loss Due to Down Tilt	1 dB	2 Degree Down Tilt Assumed
(M)	Effective Antenna Gain	16.5 dBi	(H)-(I)-(K)

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The propagation loss between the two BTS sites can be estimated using free space loss (FSPL) formula as below:

$$FSPL = (4\pi d/\lambda)^2 = (4\pi df/c)^2$$

$$FSPL\ (dB) = 10\log((4\pi df/c)^2) = 20\log(d) + 20\log(f) + 20\log(4\pi/c) = 20\log(d) + 20\log(f) - 147.56$$

Where "d" is the distance between transmitter and receiver antenna, and "f" is the signal frequency.

For f=878MHz and d= 200 m:

$$FSPL = 77.33\ dB$$

And the total path loss (PL) would be:

$$PL_1 = (b) - (f) + FSPL - (m) + (g) = +2 - 10 + 77.33 - 16.5 + 2 = 54.83\ dB$$

If both BTS sites are co-located, the isolation between antennas will replace the free space loss, and the following calculations can be used to estimate the path loss. The antennas are assumed to be separated vertically at the same tower.

$$PL_2 = (b) + \text{Antenna Isolation} + (g)$$

The assumptions state that the two antennas are at an equivalent altitude and that they are pointing into the "null" of the interferer. In many instances this may not be the case. The interferer may point directly into the peak of the receive antenna and decrease the path loss, thereby making the attenuation requirements of the filter higher. An interfering antenna with a tilt into a receive antenna may also degrade the receiver performance more than what has been indicated in this paper.

3. Out-Of-Band Emission Problem

First, the tolerable receiver sensitivity degradation should be defined. It is estimated that 0.5dB of sensitivity degradation could result in as much as 6% coverage loss. Therefore, set the maximum tolerable interference level at the receiver so that the sensitivity degradation is less than 0.5dB. This is achievable by keeping the noise rise less than 0.5dB at the receiver.

$$\text{Receiver Noise Level} = N = K_B \times T \times B \times (nf)$$

Where

K_B = Boltzmann constant = 1.38×10^{-23} ($WK^{-1}\ Hz^{-1}$)

T = Temperature (K)

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B = Receiver Noise
Bandwidth (Hz) nf = Noise
Factor

Calculating for T = 300 K, B = 3.84 MHz (UMTS bandwidth), nf = 3.16 (Noise Figure of 5 dB):

$$N = 1.38 \times 10^{-23} \times 300 \times 3.84 \times 10^{6} \times 3.16 = 5 \times 10^{-14}\ W$$

The interference comes from out-of-band emission of the 850 MHz BTS site; "I", is added to the receiver noise level. In order to keep the sensitivity degradation below 0.5dB, "I" should be:

$$\text{Sensitivity Degradation} = \Delta S < 0.5\ dB \Rightarrow 10 \log (N+I) - 10 \log(N) < 0.5$$

$$\Rightarrow (N + I) / N < 1.122$$

$$\Rightarrow I < 0.61 \times 10^{-14}\ W = -112.15\ dBm = I_{max}$$

Then, estimate the permissible level of the out-of-band emission specified by 3GPP. This depends on the transmitter technology (UMTS in this example) and the guard band between the wanted and unwanted signals. For instance, the leakage to the immediately adjacent carrier frequency can be as high as +1 dBm for the 46 dBm output power.

Considering 1 to 2 MHz guard band between the transmitter (i.e. Carrier-2) and the receiver (i.e. Carrier-1) frequency bands, the limit for the out-of-band transmission is -13 dBm / MHz. Hence, for 3.84 MHz of bandwidth we have:

$$\text{Out-Of-Band Emission Power} = P_e = -13 + 10 \log(3.84) = -13 + 5.84 = -7.16\ dBm$$

For 200 m site-to-site distance, the interfering signal that reaches the receiver ("I") is:

$$I = P_e - PL_1 = -7.16 - 54.83 = -61.99\ dBm$$

This level is far more than the permissible level for the interfering signal at the receiver. Therefore, this out-of-band emission signal should be attenuated by fitting a filter at the transmitter site (i.e. Carrier-2 BTS).

$$\text{Attenuation Required} = I - I_{max} = -61.99 - (-112.15) = 50.16\ dB$$

Similarly, the required attenuation can be calculated for different site-to-site distances, as shown in table 2.

Table 2

Distance (m)	PL_1 (dB)	Interfering Signal Power (dBm)	Attenuation Required (dB)
50	42.8	-49.96	62.19
150	52.33	-59.49	52.66
700	65.71	-72.87	39.28
1300	71.09	-78.25	33.9

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For the co-location scenario, the required attenuation would be as follows:**Table 3**

Vertical Antenna-to-Antenna Distance (m)	PL2 (dB)	Blocking Signal Power (dBm)	Attenuation Required (dB)
1	45.8	-52.96	59.19
2	56	-63.16	48.99
3	62	-69.16	42.99
5	69.6	-76.76	35.39

As stated above, the calculations include a number of assumptions. The attenuation required also depends on:

- The technology (i.e. LTE, UMTS, GSM, etc.) used in the receiver and interfering BTS sites
- The delta between the wanted and blocking signal frequencies
- Different antenna specifications
- Antenna bearing and tilt
- The number of interfering BTS sites

4. Conclusion

As indicated, there is an obvious need for filtering on the both 850 MHz and 900 MHz BTS sites to protect the receivers and maintain the quality of the uplink connection. It should be noted that the assumptions in this paper are not simulating the worst case scenario, and the required attenuation might be more as:

- Each 900 MHz site could be affected by more than one 850 MHz site (which is the case in practice)
- The distance between 850 MHz and 900 MHz BTS sites could be less
- As per antenna height, tilt and bearing (e.g. the 850 MHz antenna azimuth could be directly toward the 900 MHz BTS antenna).

Kaelus assists network operators in assessing this problem globally and recommends solutions that are implemented and
proven to improve network quality and coverage. For additional information on our products and services contact us at www.kaelus.com or through our global technical sales and support offices.

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