Evaluation of Co-existence interference between CDMA 1900MHz & WCDMA 2100MHz

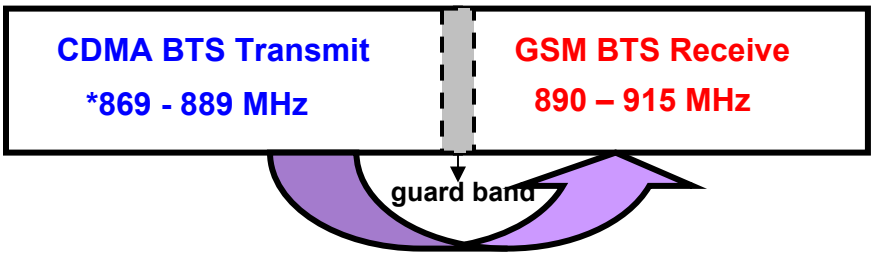
October 2007

Detailed interference analysis report prepared by AUSPI for co-existence of CDMA/EVDO & GSM/WCDMA in 1900MHz frequency band

1. INTRODUCTION

Spectrum is a scarce resource and with increase in tele-density and subscriber numbers, there is need for additional spectrum. In the 1900MHz band, there is an overlap of spectrum (1930MHz-1980MHz) between CDMA & WCDMA systems. However, there is 1900MHz-1910MHz paired with 1980MHz -1990MHz band that is exclusively used by CDMA/EVDO.
There are deployments in the 1900MHz band for WCDMA & CDMA systems [Example: Philippines]. Coexistence of different cellular communication systems that share the same frequency band is becoming one of the most efficient ways to use the spectrum.

Both CDMA (IS-2000) as well as GSM technologies presently co-exist in the 850MHz band across many telecom Circles in India. This establishes a fact that the technologies can co-exist within the same frequency band.



**This is as per the CDMA frequency allocations specific to India*

FIGURE-1

A field trial with detailed analysis was initiated by AUSPI on request from Department of Telecom-India to analyze if the WCDMA band (1920MHz to 1980MHz) is interfered by the CDMA band (1980MHz to 1990MHz). This field trial was held at Hyderabad by setting a test network of 5 BTS sites.

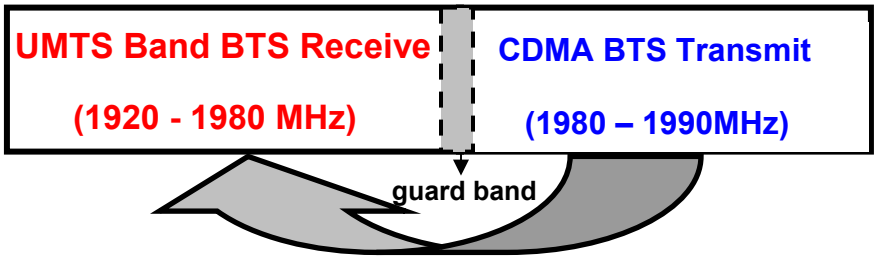


FIGURE-2

The intent of this paper is to analyse if the WCDMA system gets interfered if the CDMA carrier operates in 1980MHz to 1990MHz. There could be some potential interference scenarios between WCDMA (UMTS/IMT-2000) and CDMA (IS2000/EVDO) systems to co-exist in adjacent channels in 1900MHz band; some of them are listed below:

1. CDMA BTS Tx interfering WCDMA Rx
2. CDMA MS Tx interfering WCDMA Rx
3. CDMA MS Tx interfering WCDMA UE Rx
4. CDMA BTS Tx interfering WCDMA UE Rx
5. WCDMA Tx interfering CDMA BTS Rx
6. WCDMA UE Tx interfering CDMA BTS Rx
7. GSM/WCDMA UE Tx interfering CDMA MS Rx
8. GSM/WCDMA Tx interfering CDMA MS Rx

The most critical of the above mentioned interference scenarios are CDMA BTS Tx interfering WCDMA Rx.

Interference within the adjacent frequency bands can be mitigated if the isolation requirements between the two systems are met. Two critical factors, which add up to, the interfering signals for adjacent bands are:

- OOBE [Out of Band Emission]
- ACS [Adjacent Channel Selectivity]

OOBE [Out of Band Emission]

Spurious emissions from the CDMA transmit frequency in the adjacent WCDMA/GSM band causing interference. Table-1 provides the OOBE requirements for different guard bands between the CDMA & WCDMA/GSM frequencies.

	WCDMA	**WCDMA**
Receive	WCDMA& CDMA GuardBand > 1.625Mhz	WCDMA& CDMA GuardBand <1.355Mhz
Noise Floor [dBm]	-108.2	-108.2
S/N + NF [dB]	4	4
SENSITIVITY	**-104.2**	**-104.2**
Interference Margin dB]	-10	-10
Interference Signal [dBm]	-114.2	-114.2
Transmit		
BTS Output [dBm]	43	43
CDMA OOBE [as per 3GPP2 standards]	-13 [4]	-45 [4]
Units	dBm/1Mhz	dBc/30khz
Channel gain [Normalisation] [dB]	6.2	21.5
CDMA OOBE Power dBm]	-6.8	19.5
Required Isolation [dB]	**107.4** [1][2][3]	**133.7**

Table-1

References used for Table-1:

[1] AUSPI presentation to TRAI on spectrum response to COAI
[2] European Radio Communications committee – ERC Report 65 (Noise Floor: -103 dBm)
[3] IEEE – Evaluation of coexistence between PCS 1900 and UMTS in an outdoor Environment (Isolation – 103 dB)
[4] 3GPP2 specification for OOBE requirements

ACS [Adjacent Channel Selectivity]

This is the out-of-band signal that the WCDMA/GSM receiver picks up from the adjacent channels.

CDMA Transmit Power [dBm]	43
Adjacent Channel Signal level [dBm]	-52 [5]
Required Isolation [1920Mhz to 1980Mhz] [dB]	**95**

Table-2

References used for Table-2:

[5] 3GPP2 specification for ACI

Table-1 & Table-2 provide us the minimum isolation requirements for the WCDMA & CDMA systems to co-exist in 1900MHz band.

2. NETWORK SETUP

Test network was setup in the CBD area of Hyderabad, India. Total of 5 sites were selected in the dense urban & urban morphologies to simulate real life deployment scenario. All the 5-sites were co-located with CDMA & WCDMA BTS in 1900MHz band with seperate antenna systems. A detailed test approach was carried out to measure the interference and performance results in a collocated CDMA1900 & WCDMA scenario. These 5 sites were connected to the standalone CDMA and WCDMA core network [RNC/BSC/MGW/MSC].

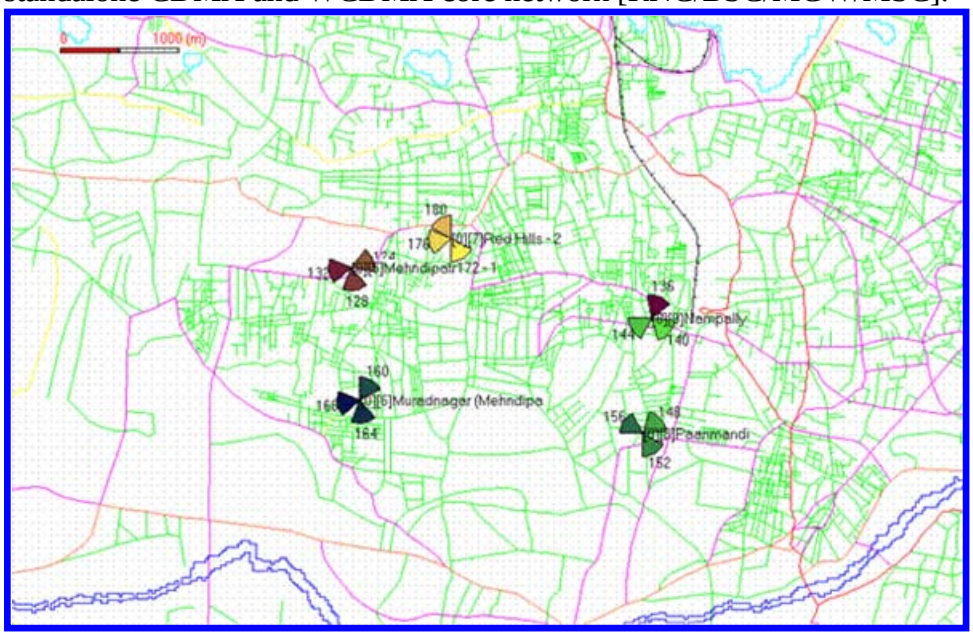


FIGURE-3

Site Details:

		CDMA		WCDMA			
Site Name	**Sector**	**Azimuth [deg]**	**Tilt [deg]**	**Azimuth [deg]**	**Tilt [deg]**	**Vertical Seperation between CDMA & WCDMA antenna [meters]**	**Horizontal Seperation between CDMA & WCDMA antenna [meters]**
Muradnagar	Alpha	80	0	80	0	2.5	1
	Beta	190	0	190	0	2	1
	Gamma	340	0	340	0	1.9	1
PanMandi	Alpha	40	0	40	0	2.5	1
	Beta	120	0	120	0	2.5	1
	Gamma	330	0	330	0	1.8	1
Nampally	Alpha	30	0	30	0	1.5	1
	Beta	160	0	180	0	1.7	1
	Gamma	240	0	260	0	1.7	1
RedHills	Alpha	140	0	140	0	1.5	10
	Beta	240	0	240	0	1.5	10
	Gamma	330	4	350	0	1	15
Mehdipatnam	Alpha	60	0	60	0	1	5
	Beta	170	0	170	0	1	1.5
	Gamma	280	0	280	0	0	34

Table-3

2.1 Test & Measurement Methodology:

There were 2-WCDMA & 3-CDMA/EVDO carriers provided for the test network. Below given figure mentions the centre frequencies used for CDMA/EVDO channel (1.25MHz) and WCDMA channel (5MHz) for the test network.

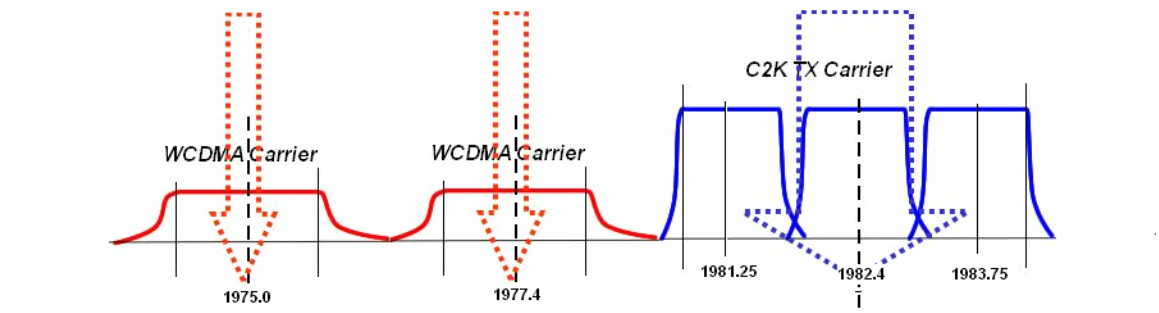


FIGURE-4

Table below mentions the isolation requirement for different CDMA downlink & WCDMA uplink frequency pairs:

WCDMA Center Frequency [Mhz]	CDMA Center Frequency [Mhz]	Center-Center Seperation [Mhz]	Isolation Requirement [dB]
1977.4	1981.25	3.85	133.6
1977.4	1982.4	5	107.4
1977.4	1983.75	6.35	107.4
1975	1981.25	6.25	107.4
1975	1982.4	7.4	107.4
1975	1983.75	8.75	107.4

Table-4

This table indicates that the isolation requirement for Center-to-Center separation of 3.85MHz is more stringent 133.6dB.

Antenna Specifications:

The antennae used in this test network were off-the-shelf most commonly deployed ones for CDMA & WCDMA networks.

Vendor	MOBI			
TYPE	MB3F-65-18DT2			MB1900-65-17D
Technology Used for:	WCDMA			CDMA
Electrical Specifications				
	1710-2170			1850-1990
Frequency Range(MHz)	1710-1880	1850-1990	1920-2170	
Gain(dBi)	17.5	17.7	18	16.7
Polarization	±45°	±45°	±45°	±45°
Horizontal-3dB Beamwidth(°)	65	63	63	65
Vertical-3dB Beamwidth(°)	7	6.5	6	8.5
Electrical Downtilt(°)	2	2	2	0
First Upper Sidelobe Suppression(dB)	≥15	≥15	≥15	≥15
Cross polar ratio				
Maindirection 0°	Typicall y: 20	Typicall y: 20	Typical ly: 20	≥15
Sector ±60°	≥10	≥10	≥10	
Front-to-Back Ratio(dB)	≥25	≥25	≥25	≥30
V.S.W.R	< 1.5	< 1.5	< 1.5	< 1.4
Isolation Between Two Ports(dB)	≥30	≥30	≥30	≥30
PIM3(dBm)	< -107			< -107
Impedance(Ω)	50			50
Lightning Protection	Direct Ground			Direct Ground
Maximum Input Power(W)	200			500

WCDMA Antenna [MB3F-65-18D2]

CDMA Antenna [MB1900-65-17D]

3. TEST RESULTS

These are the important contributors for attaining the required isolation in the adjacent frequency bands:

- Power Amplifier
- Duplexer rejection:
- Antenna spacing

The basic block diagram used to measure the rejection levels for each of the above contributor is as shown below in figure-2.

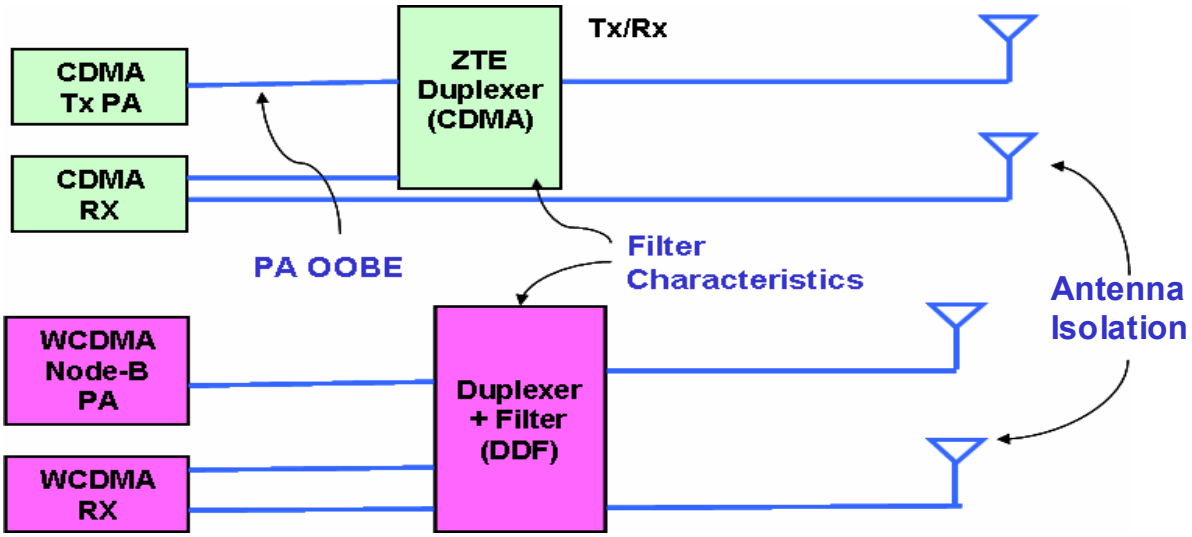


FIGURE-5

3.1 Power Amplifier

OOBE or spurious emission from the CDMA transmit frequency will be primarily rejected by the CDMA BS power amplifier. The graph below provides the CDMA BS power amplifier rejection values for different frequency pairs.

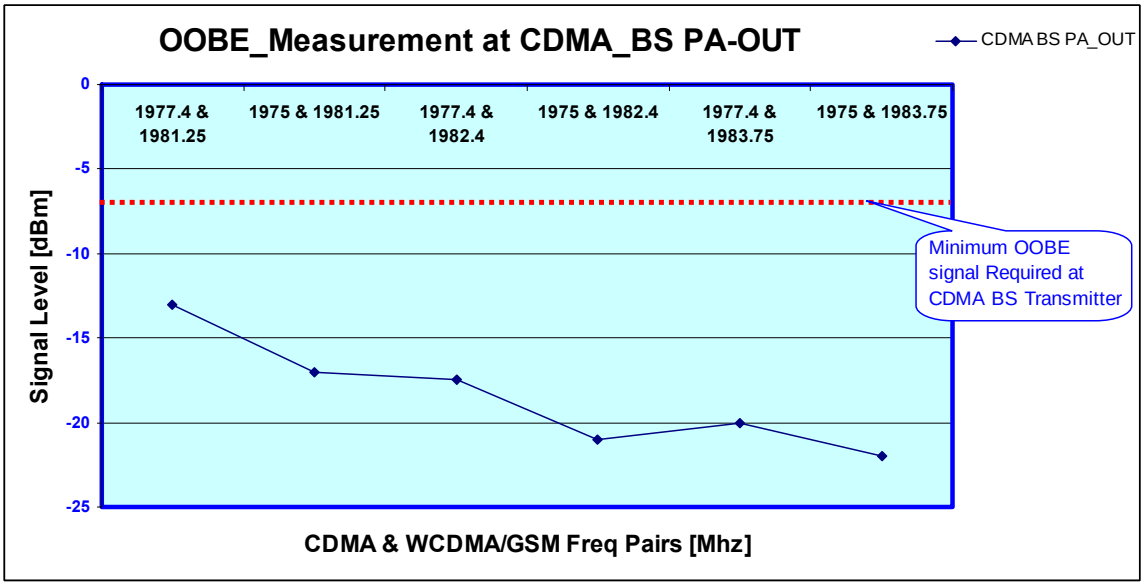


FIGURE-6

Figure-3 clearly indicates that the CDMA_BS power amplifier provides much better rejection for OOBE than required as per 3GPP2 standards.

3.2 Duplexer rejection:

The Duplexer rejection/insertion loss was recorded at different frequency spots in WCDMA & CDMA band. Table-3 below mentions the rejection/insertion loss values observed for the commercially available CDMA & WCDMA duplexer.

FIGURE-7

Figure-4 indicates that the CDMA duplexer provides 32dB to 38dB rejection to the WCDMA band frequencies.

Similarly the WCDMA duplexer characteristic at different frequency spots is given below in figure-5.

FIGURE-8

Figure-5 shows that the commercially available WCDMA duplexer can provide upto 51dB rejection for the CDMA band frequencies.

It can be observed from figure-5 that the WCDMA duplexer could only provide 7dB rejection for the 1st CDMA carrier [1980.625MHz to 1981.775MHz]. This observation implies that the WCDMA duplexer does not provide enough rejection to the Adjacent Channel. We will see later in the paper the effect of this observation on the ACS requirements.

3.3 Antenna spacing

This is one of the important parameter as it is highly dependent on the real life antenna deployments. The CDMA/EVDO & WCDMA antennas could be installed as close as 1mtr horizontal on the same plane and serving in the same direction. The antenna isolation values were recorded for different horizontal and vertical spacing between the CDMA/EVDO & WCDMA antennas.

Formula used for calculating the antenna isolation for horizontal distance:

$22 + 20LOG[D/L]-[G_{WCDMA}+G_{CDMA}]$ *[1]*

Where;

D is the horizontal distance between CDMA & WCDMA antenna [mtr]

L= Lambda

$G_{WCDMA=}$ *Gain of WCDMA antenna in the direction*

$G_{CDMA=}$ *Gain of CDMA antenna in the direction*

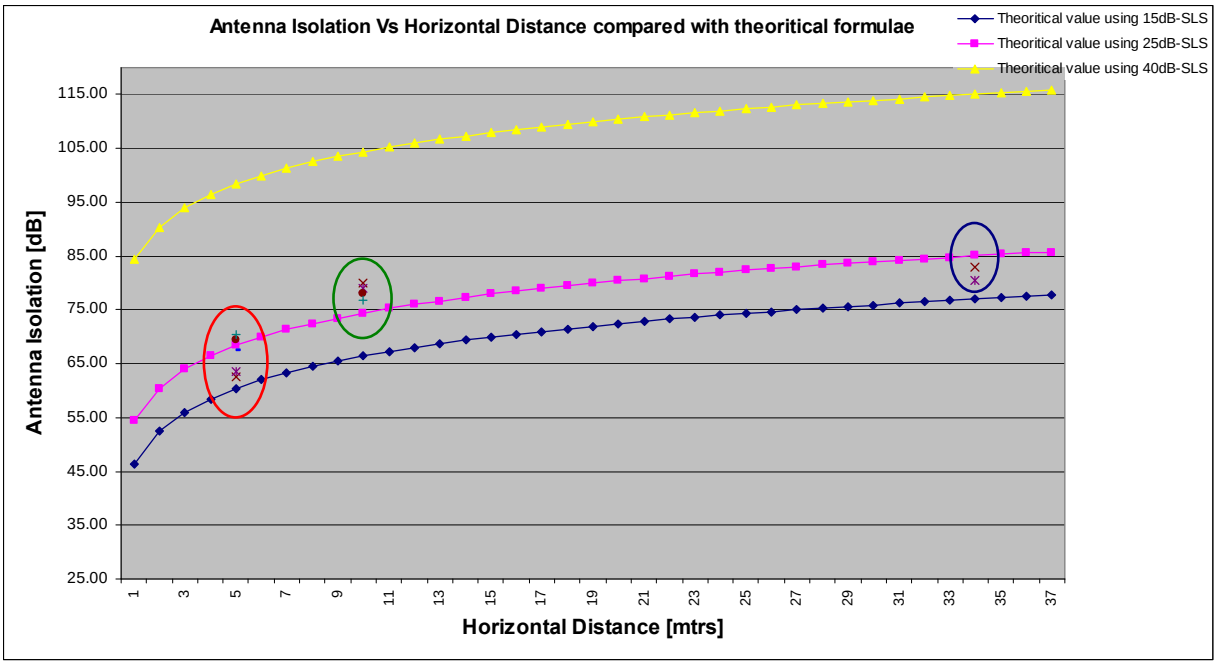


FIGURE-9

Figure-6 shows the antenna isolation values achieved with different horizontal distances [5mtr, 10mtr, 34mtr]. The antenna isolation values recorded on field are much better than the theoretical calculation using the formula [1] mentioned above.

Formula used for calculating the antenna isolation for horizontal distance:

$28 + 40LOG[D/L]$ *[2]*

Where;

D is the vertical distance between CDMA & WCDMA antenna [mtr]

L= Lambda

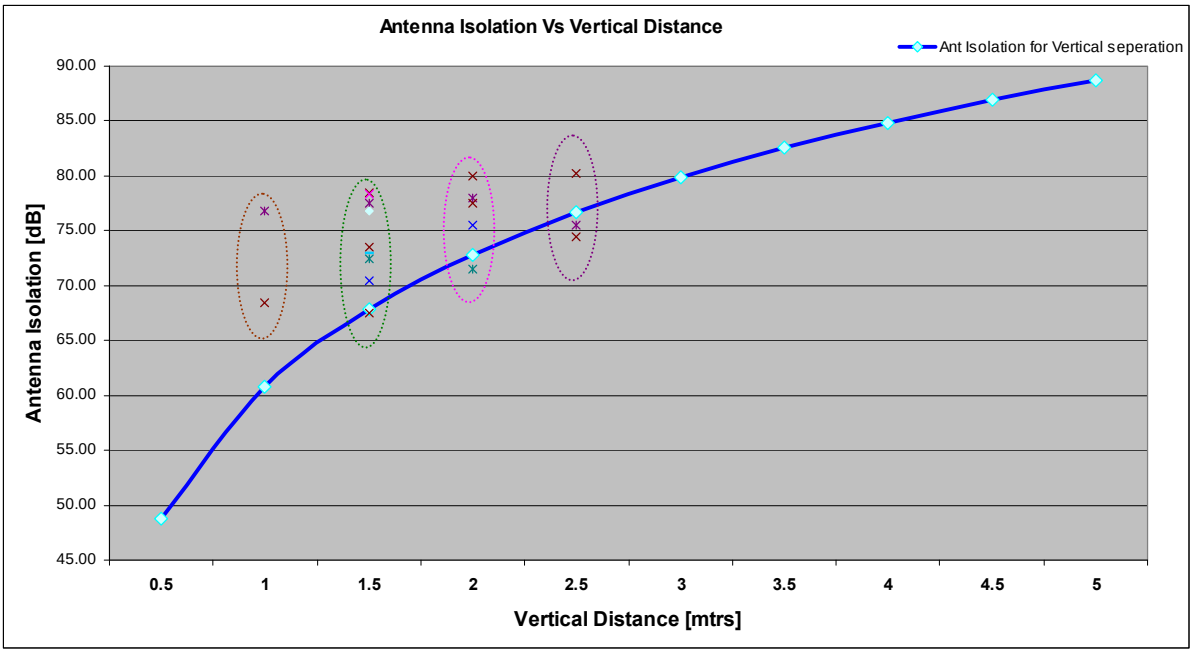


FIGURE-10

Above Figure shows that the antenna isolation values achieved in the field test for different vertical separation between CDMA & WCDMA antennas is better than the theoritical values using formula [2].

Site wise antenna isolation values achieved for different vertical & horizontal spacing between the antennas is shown in below table.

		CDMA		WCDMA				
Site Name	**Sector**	**Azimuth in degrees**	**Tilt in degrees**	**Azimuth in degrees**	**Tilt in degrees**	**Vertical Seperation between CDMA & WCDMA antenna [meters]**	**Horizontal Seperation between CDMA & WCDMA antenna [meters]**	**Antenna Isolation in dB**
Muradnagar	Alpha	80	0	80	0	2.5	1	**80.2**
	Beta	190	0	190	0	2	1	**80.0**
	Gamma	340	0	340	0	1.9	1	**78.0**
PanMandi	Alpha	40	0	40	0	2.5	1	**75.5**
	Beta	120	0	120	0	2.5	1	**74.5**
	Gamma	330	0	330	0	1.8	1	**77.5**
Nampally	Alpha	30	0	30	0	1.5	1	**73.5**
	Beta	160	0	180	0	1.7	1	**71.5**
	Gamma	240	0	260	0	1.7	1	**75.5**
RedHills	Alpha	140	0	140	0	1.5	10	**77.5**
	Beta	240	0	240	0	1.5	10	**78.5**
	Gamma	330	4	350	0	1	15	**76.8**
Mehdipatnam	Alpha	60	0	60	0	1	5	**79**
	Beta	170	0	170	0	1	1.5	**81.5**
	Gamma	280	0	280	0	0	34	**83**

Table-5

Table above indicates that the antenna isolation values achieved per sector range from 75dB to 83dB, giving an average of around 76dB.

CONCLUSION

It can be observed from the section 3.1, 3.2 & 3.3 that **the minimum isolation requirements (Table-1 & Table-2) for CDMA & WCDMA systems to co-exist in adjacent channels in 1900 MHz band can be met by the commercially available equipment (Power Amplifier & Filters) and antenna isolation.**
The figures below indicate that **the two critical factors for interference- OOBE & ACS can be achieved if both CDMA & WCDMA duplexers/filters can provide as good as 30dB rejection values for out of band frequencies.**
Although if the center-to-center frequency separation is more than 3.85MHz, most of the presently available commercial systems meet the CDMA/WCDMA co-existence requirements.

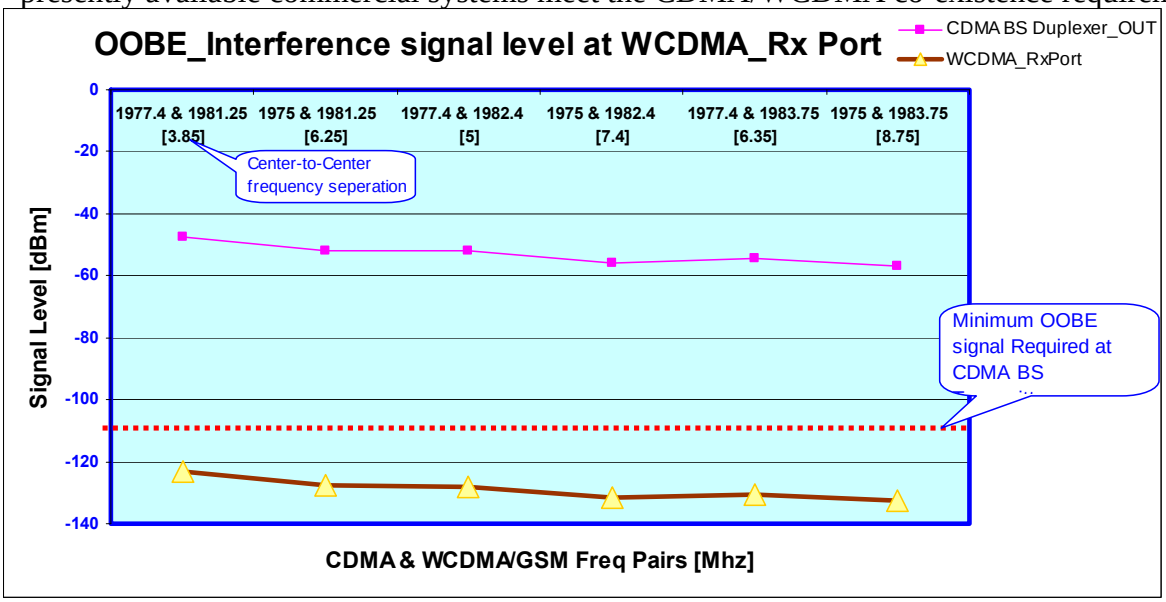


FIGURE-11

The above figure concludes that for all the CDMA carriers, the OOBE (spurious emission from CDMA carriers) is much below the required value as per standards.

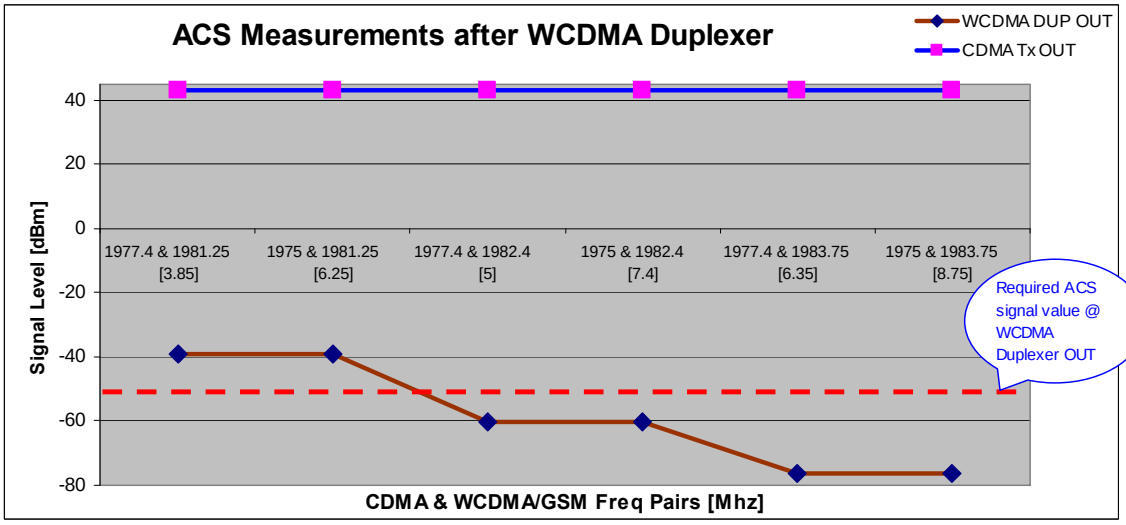


FIGURE-12

The above figure concludes that for all the adjacent CDMA carriers, the ACS requirement is met, except for the 1st CDMA carrier [centre frequency 1981.25MHz] which can also be met if WCDMA duplexer provides around 30dB rejection outside WCDMA band (1920MHz-1980MHz).

ACKNOWLEDGEMENT

AUSPI Members
Tata Teleservices Team
ZTE Team

REFERENCES

[1] AUSPI presentation to TRAI on spectrum response to COAI
[2] European Radio Communications committee – ERC Report 65 (Noise Floor: -103 dBm)
[3] IEEE – Evaluation of coexistence between PCS 1900 and UMTS in an outdoor Environment (Isolation – 103 dB)
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