Adjacent Band Compatibility Study for S-band RDSS/RNSS

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Contents

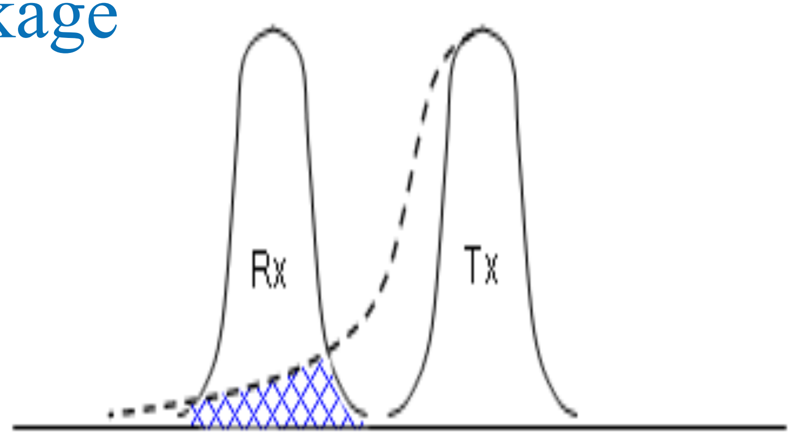
RDSS/RNSS Adjacent Band Compatibility

- 2483.5-2500MHz used for RDSS/RNSS
  - ✓ Before 2012, primary service, only in parts of the world.
  - ✓ WRC-12 , primary service, all over the world.
- 2400-2483.5MHz used for WLAN
- 2500-2690MHz used for IMT
- **WLAN and IMT are adjacent to RDSS/RNSS that could cause unacceptable interference to RDSS/RNSS.**

Interference Principle(1)

➢ **In-band Interference**

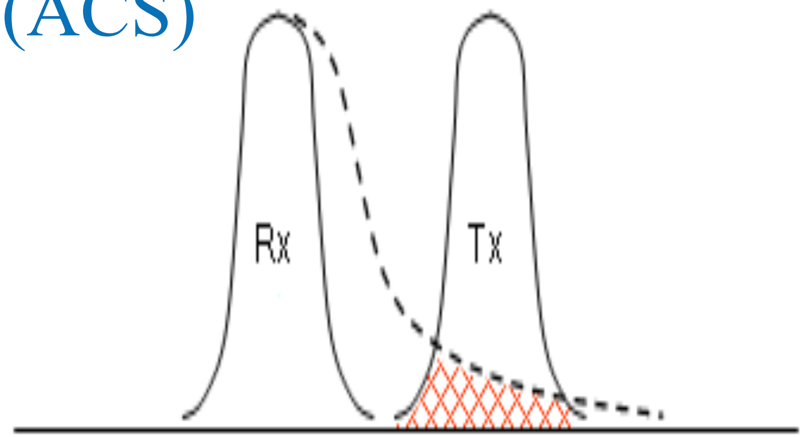
- Refer to the reduction of the receiver sensitivity
- Caused by the out-of-band unwanted radiation from interfering system into the desired system receiver
- Adjacent Channel Leakage Ratio (ACLR)



Interference Principle(2)

➢**Out-of-band Interference**

- Refer to receiving unwanted signals without enough choice at the out-of- band
- Cuased by receiving interfering system signals with the non-ideal filters of the desired system receiver
- Adjacent Channel Selectivity (ACS)
  Blocking Characteristic



Compatibility Analysis Method

- For inter-service coexisted in **cofrequency band**
  - –Link-budget-based deterministic analysis method
    - •Simply and effectively
    - •Adapted for the qualitative and quantitative analysis of interference.from a single station to a single station.
- But for inter-service coexisted in **adjacent frequency** band
  - The above method appears incapable.
  - Spectral Separation Coefficient(SSC)
  - Aggregated Gain Factor (Gagg)

Compatibility Analysis Method

1) Definition and use of SSC

- Equal the interfering signal to the nomarlized equivalent noise power spectral densities at the frequecy of the desired signal.
- The definition of SSC is as follows:

$$\beta_{x,y} = \int_{-Bx}^{Bx} \left|\overline{H_x}(f)\right|^2 \left|\overline{H_y}(f)\right|^2 \overline{S_x}(v)\overline{S_y}(v)dv$$

- The detailed deduction refers to ITU-R M.1831.
- Then the power spectral density of interfering signal at the frequency band of disired signal can be written as follows:

$$N_{y0} = P_y + L_y + \beta_{x,y}$$

  - P_y: interfering signal power (dBW)
  - L_y: path loss (dB),

Compatibility Analysis Method

2) Definition and use of Gagg

- Assess the impact from transmit signals by multiple stations within one system on the noise floor.
- The detailed definition refers to ITU-R M.1831.
- Given Gagg and N_0 is known, $N_{x,0}$ the noise power spectral density in single station from multiple stations transmitting within one system can be written as:

$$N_{x0} = P_x + L_x + \beta_{x,x} + G_{agg}$$

– N_0: noise power spectral density of the system without any interference
– P_x : maximum transmitting power from single station
– $\beta_{x,x}$: SSC of the system signal
– Lx : signal path loss

- The sum of all noise power spectral densities is expressed by

$$N_{xeff} = N_0 + N_{x0}$$

Assumed Characteristic

1) Assumed RDSS Characteristic

Walk constellation : 27/3/1, at 56° nominal inclination

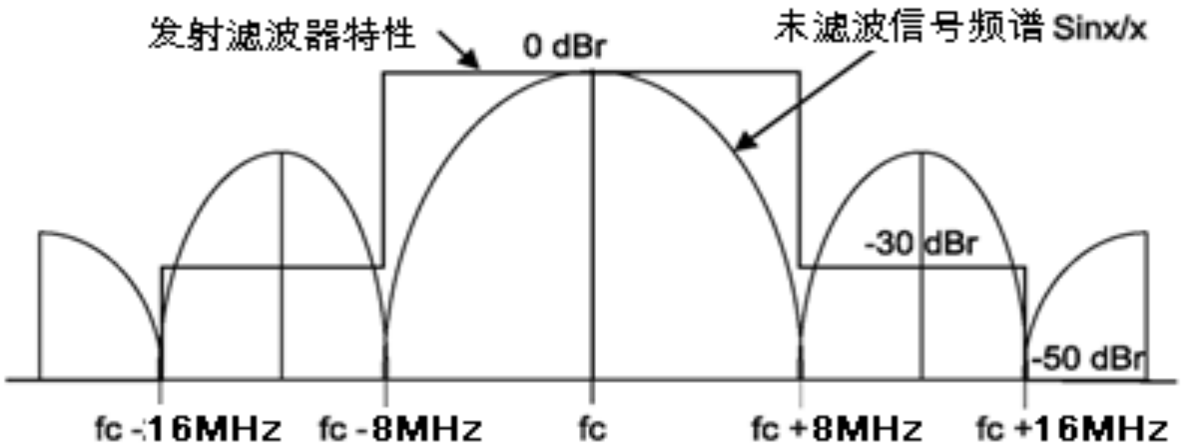
Orbit altitude :26559.8km ,   orbit eccentricity: 0.

Modulation: BPSK , code rate of 8.184MHz ,

Center frequency : 2492.028MHz.

Power : from -152dBW to -157dBW, with bit rate of 50bps/8000bps.

Convolution code with coding efficiency of 1/2 and constraint length of 7.



Assumed Characteristic

2) Assumed WLAN Characteristic

Sub-channel:14

Bandwidth : 22MHz

Power: from 10mW to100mW

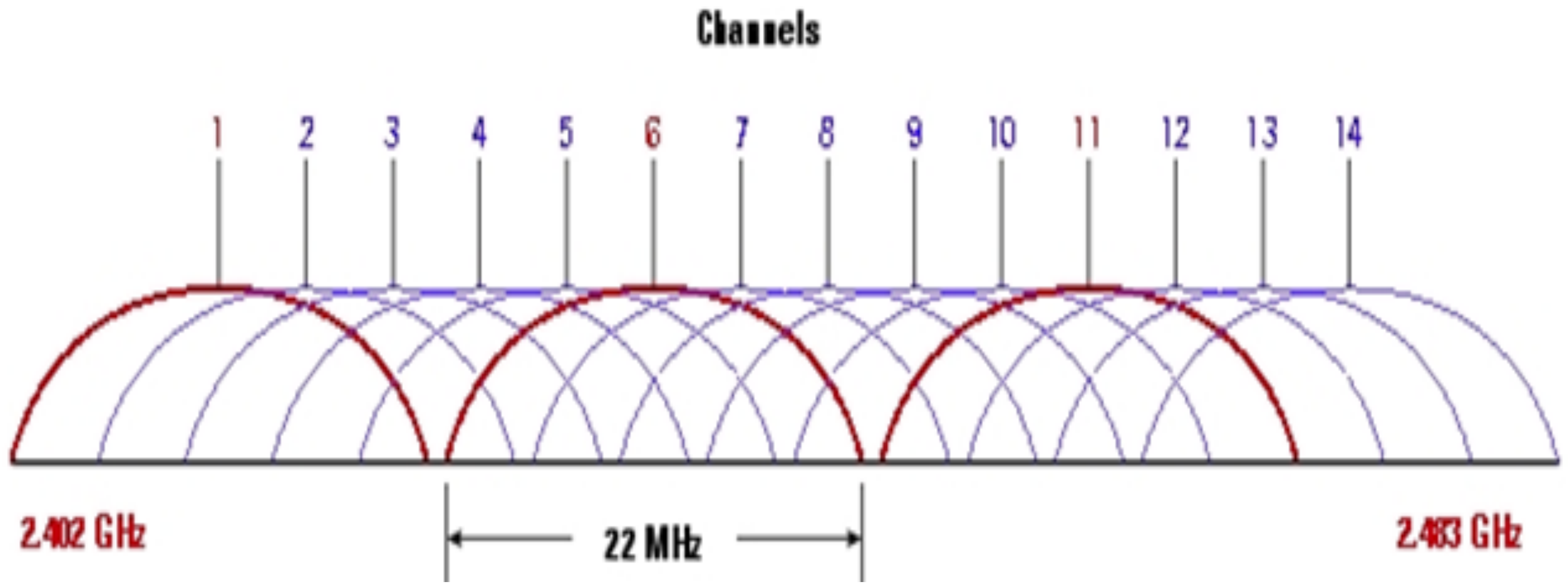
Central frequency of each channel is shown in the table,

Channel	Center Frequency	Channel	Center Frequency	Channel	Center Frequency
1	2412MHz	6	2437MHz	11	2462MHz
2	2417MHz	7	2442MHz	12	2467MHz
3	2422MHz	8	2447MHz	13	2472MHz
4	2427MHz	9	2452MHz	14	2477MHz
5	2432MHz	10	2457MHz		
note： 14^{th} channel is only used in Japan.					

Assumed Characteristic

2) Assumed WLAN Characteristic

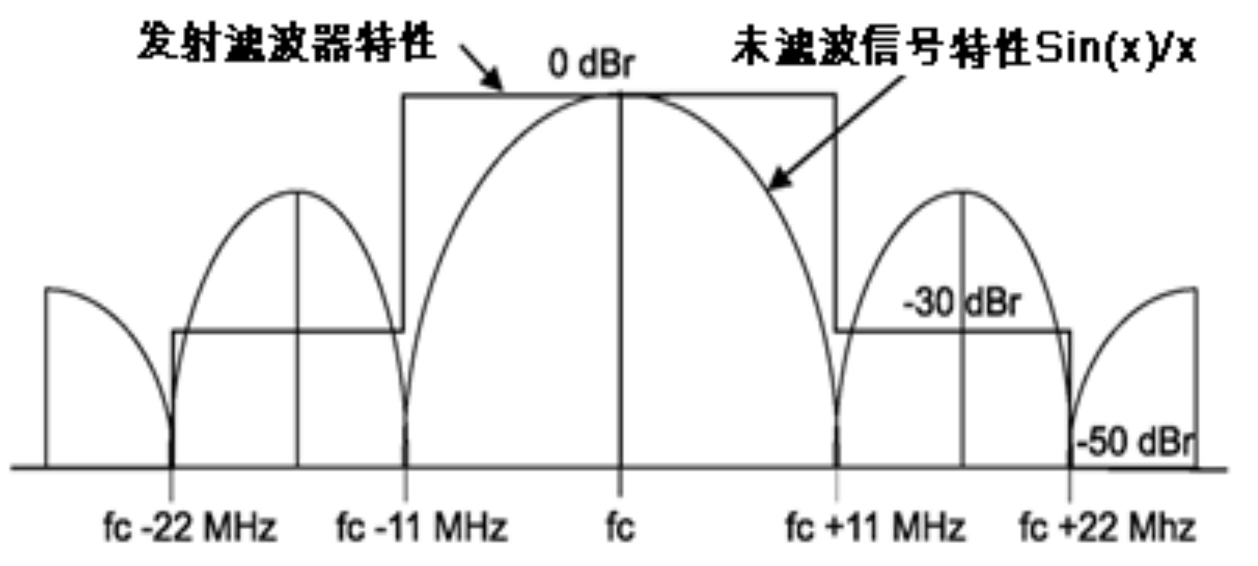
In practice, three channels in non-overlapped frequency band s are chose , such as 1, 6, 11, as shown in this figure



Assumed Characteristic

2) Assumed WLAN Characteristic

According to the IEEE 802.11-2007 standard, WLAN devices transmit power ranges from 10mW to 100mW.



Compatibility Analysis

1) G_{agg} and SSC calculation

–Only the WLAN device nearest to RDSS receiver is taken into account

–Without considering the aggregated impact of WLAN

–Gagg is 11.2dB through simulation.

–Given WLAN device uses 13th channel,

–The SSCs of desired RDSS and desired WLAN system are calculated as shown in the following table.

Desired system	Filtered RDSS（dB/Hz）	Unfiltered RDSS（dB/Hz）
RDSS	-108.2	-94.4
WLAN	-107.4	-93.6

Compatibility Analysis

2) Interference Analysis from RDSS to WLAN

–The maximum arrived power of single satellite from RDSS system is -152dBW.

–Considering Gagg and SSC

Interference power spectral densities:

- filtered RDSS to WLAN: -248.2dBW/Hz
- unfiltered RDSS to WLAN : -234.4dBW/Hz

Far lower than the signal power from WLAN device(10mW~100mW)

RDSS induces no interference onto WLAN device.

Compatibility Analysis

3) Interference analysis from WLAN to RDSS

Considering filtered WLAN, filtered and unfiltered RDSS

Interference power spectral density from WLAN to RDSS:

Distance between WLAN and RDSS receiver（m）(transmit power options: 100mW，-10dBW)	Interference power spectral density from WLAN to RDSS（dBW/Hz）	
	Filtered (ssc = -108.2)	Unfiltered (ssc = -94.4)
1	-158.5013	-144.7013
5	-172.4807	-158.6807
10	-178.5013	-164.7013
20	-184.5219	-170.7219
40	-190.5425	-176.7425

Compatibility Analysis

3) Interference analysis from WLAN to RDSS

Arrived C/N_{eff} of RDSS signal with interference

Distance between WLAN and RDSS receiver（m）(transmit power options: 100mW，-10dBW)	Arrived C/Neff of RDSS signal with interference（dBW/Hz）	
	Filtered (ssc = -108.2)	Unfiltered (ssc = -94.4)
1	1.5013	-12.2987
5	15.4807	1.6807
10	21.5013	7.7013
20	27.5219	13.7219
40	33.5425	19.7425

Compatibility Analysis

The relations between E_b/N_{eff} and C/N_{eff} is given by below equation,

$$[E_b/N_{eff}]_{dB}=[C/N_{eff}]_{dBHz}-[R_b]_{dBbps}-[L]_{dB}$$

- where:

  $[E_b/N_{eff}]$: power of per bit to noise power spectral ratio (dB)

  $[C/N_{eff}]_{dBHz}$: carrier noise power to noise power spectral ratio (dBHz)

  $[R_b]_{dBbps}$: information rate (dBbps)

  $[L]_{dB}$: dispreading and demodulation (dB)

Compatibility Analysis

Given Rb are 50bps and 8kbps respectively and the loss of dispreading and demodulation is 1dB， E_b/N_{eff} results is shown in the table:

Distance between WLAN and RDSS receiver（m） (transmit power options: 100mW，-10dB W)	**E_b/N_{eff} of RDSS with interference dBW/Hz）**			
	Filtered (ssc = -108.2)		Unfiltered (ssc = -108.2)	
	Rb=50bps	Rb=8kbps	Rb=50bps	Rb=8kbps
1	-16.4987	-38.4987	-30.2987	-52.2987
5	-2.5193	-24.5193	-16.3193	-38.3193
10	3.5013	-18.4987	-10.2987	-32.2987
20	9.5219	-12.4781	-4.2781	-26.2781
40	15.5425	-6.4575	1.7425	-20.2575

Note： WLAN device (excluding antenna gain, and transmitting signals according to standard values rigidly).

Analysis results

- There is no interference from RDSS to WLAN service in S band.

- If WLAN service use the adjacent frequency to the RDSS in S band, there could be unacceptable harmful interference to RDSS from WLAN.

Conclusion

- If WLAN used in open air, its channel using and transmitting power should be rigidly controlled.
- We propose that the RDSS/RNSS adjacent frequency compatibility study in the L,S,C band should be conducted based on the real system characteristic.
- To promote setting the protection standard of RDSS / RNSS service from adjacent frequency service in the L,S,C band under the ITU framework.

Thanks for your attention!

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