Guidance regarding contention based protocol for devices operating in the 3650-3700 MHz Band under Part 90Z

Document Overview

This document identifies several questions / information to help determine the contention based protocol capability of a device that may operate in the 3650 – 3700 MHz under part 90Z of our rules. These questions are intended to be used as a guide by the applicant to describe how their system meets the requirements for 3650-3700 contention based protocol. The list is not intended to be exhaustive and may be modified in the future. There may be follow-up questions based on the responses provide by the applicant for authorization.

Applicants seeking certification for systems as complying with restricted contention based protocol (3650 to 3675 MHz) that permit operation on a co-channel with like systems (similar systems) may seek equipment authorization from a Telecommunications Certification Body (TCB) using the Permit but Ask procedure as described in Section 3 .

Applicants seeking certification for systems as complying with the unrestricted contention based protocol for operation in the 3650 to 3700MHz band that permit operation on a co-channel with similar or different systems (recognizing other systems) must apply to the FCC for equipment authorization.

1. Restricted Certification under Part 90Z (3650-3675 Band)

In order to ensure that a device complies with the requirements of restricted contention based protocol, the following information should be provided in the application.

1.1. Restricted Protocol Description

1.1.1. Although the restricted protocol does not have the extended requirement to recognize all other systems it is still mandatory to incorporate a contention based protocol that provides satisfactory sharing of spectrum with similar systems.

1.1.2. Address the key requirements for operation using restricted contention based protocol opportunities for other transmitters to operate. Please note that this requires recognizing like systems (similar to yours) that permit operation on a co-channel.

1.1.3. Provide any additional manuals and operational descriptions to allow the reviewer to understand the product and its operation.

1.2. Describe the method to permit occupancy

1.3. Describe the action taken if two or more transmitters simultaneously access the same channel by the master and the client devices.

1.4. Describe opportunities for other similar systems to operate. Address how or if a different system operator using the same technology can operate in the same band.

2. Unrestricted Certification under Part 90Z (3650-3700 Band)

In order to ensure that a device complies with the requirements of unrestricted contention based protocol, the following information should be provided in the application.

2.1. Unrestricted Protocol Description

Address the key requirements for operation using unrestricted contention based protocol. Please note that this requires recognizing other systems (both similar to yours and different from yours) that operate on a co-channel. Indicate the strategy for sharing the spectrum in terms of: Does the system use spectrum sensing to determine if the other devices are transmitting and then find ways to share the bandwidth, or Have some other strategy?

2.2. Threshold detection to determine occupancy

2.2.1. Describe how your system determines if another system is using the spectrum. At what detection level – relative to 0 dBi receive antenna gain (busy channel threshold) does the device determine if another system is operating on the spectrum?

Answer:

- One of the important parameters, the WiMax TDD (Time-Division Duplex) system measures, is the environment noise level. The Base Station (BST - the master) is measuring the noise level in the initialization phase (before the start of any transmission). It also measures the noise level, every configured frame number, during operational time.
- The system can operate in 10MHz BW (bandwidth) or 5MHz BW. Based on 10MHz BW, the noise level with no interferences is detected. If no interference, the noise level will be below -92dBm (10MHz BW assuming 0dBi receive antenna gain). If there is interference the noise level is increased above -92dBm and determines that another system is operating on the same frequency spectrum.
- In addition the system provides opportunity to other systems, by freeing the current frequency, every configured number of frames (default=200 frames=1sec) for configured number of frames (default=200)

2.2.2. How long does the system observe to determine if the channel is busy – at the initial time and in between communications?

Answer:

- The observation time is taken in the initialization processes, right after power on (before starting to transmit), during 500msec.
- Also observation is made during normal operation, in frames/slots that are not occupied by users (clients). The base-station take care that there will be free slots, for observation.

2.2.3. What is the bandwidth being monitored versus bandwidth occupied for all modes of operation?

Answer:

- The BW being monitored is according to the operational BW. In case of 10MHz operation the BW being monitored is 10MHz.

2.2.4. How much variability is provided to the system operator to adjust busy channel detection threshold?

Answer:

- The default value of the threshold, to define busy channel, is -92dBm. The configuration range is between -62dBm to -92dBm.

2.2.5. What is the operating system threshold (receive threshold) compared to the monitoring threshold (busy channel threshold)?

Answer:

- Operating system threshold (Receive threshold) and busy channel threshold are configurable. The range is -88dBm to -97dBm. Default thresholds, are:
  - Receive threshold: lower than -92dBm
  - Busy channel threshold: higher or equal to -92dBm

2.2.6. What additional checks does the system perform to determine if the spectrum is being used before initiating a transmission?

Answer:

- Beside the noise measuring, during initialization, the BST is observing the channel, in clear frames/slots, where no activate remote station is transmitting to the BST. The BST always leaves empty slots, in each frame, for observing the channel.

2.2.7 Do the master and the client perform the threshold detection? If master only performs the detection how does it determine if the client may interfere with the other system (hidden node detection mechanism)?

Answer:

- As been said before, the master performs threshold detection. On initialization case, it will start transmission, only after it will find a "clear" frequency. The remote station will not transmit until they will be synchronized to the master transmission, in the "clear" frequency. So, they will not interfere. On normal operation, the remote station's transmission is controlled by the master, so the remote will not transmit, without the master instruction, by receiving precise transmission map.
- In case master detect noisy channel, it will stop transmitting immediately and look for another "clean" frequency. Automatically, all remote station will lose synchronization and would not transmit, since it has no transmission permission.
- The remote station has additional mechanism, for detecting noisy channel. The remote station is autonomously stop transmission, when noise increases above configured threshold. First, it starts scanning for better frequency. Then, when noise increases above higher threshold, it hands over to the "cleaner" frequency. (This is part of its handover implementation.)

2.3. Action taken when occupancy is determined

2.3.1. What action does your system take when it determines occupancy? Does it vacate the channel or does it have some back-off and retry strategy? What is the impact of traffic on the spectrum sensing or avoidance performance?

Answer:

- When the system determines occupancy, the master will change the frequency to a "clear" frequency. As described above, the decision is made by the BST, when it detect that channel is occupied. At this point, the occupied frequency is vacated. Also after moving to "clear" frequency, the BST keeps measuring the noise, in each frame. If the current frequency is noisy, it may return to the original frequency, if it's clear. The impact on traffic and performances is minor, since it's been done on very short times (few milliseconds).
- As mentioned in paragraph 2.2.7, the remote autonomously stop transmission, when it detect noisy channel.

2.3.2. If you use other means, please describe how the device determines the existence of other systems and what steps it takes to either share the channel or avoid its use.

Answer:

- As mentioned in paragraph 2.2.7, the remote station has its mechanism, for autonomously stop transmission, when it detect noisy channel.

2.3.3. Describe any mechanism that would limit a transmission from a remote station if only the master detects occupancy (hidden node avoidance mechanism).

Answer:

- The master that detects high noise is stopping to transit immediately and will change it transmission frequency to clean one. The remote stations will not get allocations to transmit, since they will lose synchronization, so they will not transmit anything, without being instructed to. The master informs its new frequency to its neighbor masters (in the backbone). All the system is synchronized and all the remote stations will scan pre-configured frequencies, and synchronized to the new frequency autonomously. As been said in item 2.2.7, remote station will not transmit, without the master instructions. As a result the remote station is not transmitting in occupied frequency.
- It should be emphasized, as mentioned in paragraph 2.2.7, that remote station will prevent its transmission, autonomously, when it detects noisy frequency.

2.4. Opportunities for other transmitters to operate

2.4.1. When describing occupancy profile, clarify any differences between start-up acquisition mode of spectrum and operational modes.

Answer:

- In startup mode (initialization time), the BST is measuring the environmental noise, taking into account the RF parameters of its RF module (NF, etc…). The BST will not start to transmit if the channel noise is above configured threshold (default = -92dBm), as indicated in 2.2.5, and will scan after a new frequency to find clear one.
- In normal operational mode, the BST is measuring the noise in clear frames/slots, when no remote station is transmitting. The BST allocates the remote stations transmitting frames and knows when frames/slots are clear. If noise level is above threshold, the BST vacate the noisy frequency and move to "clean" one. The busy channel threshold in operational mode is the same threshold, as in startup mode.

2.4.2. In operational mode, how long does the system transmit before stopping giving others a reasonable time to transmit before continuing?

Answer:

- As been said, in paragraph 2.2.1 above, the system provides opportunity to other systems, by freeing the current frequency, every configured number of frames (default=200 frames) for configured number of frames (default=200). Just to emphasize, no transmission is made, once channel is found busy.

2.4.3. Does the system (master and / or client) listen prior to every transmission? If no, explain.

Answer:

- The master and client listen prior to every transmission.

2.4.4. Describe how the operational spectrum usage (on air time) is dependant on system load conditions (no load, typical and overload). For example, if a station does not have any information to transmit describe any regular or recurring transmission that may take place?

Answer:

- In any case, after initialization process finished successfully, the BST will transmit 1 Preamble symbol and 2 or 4 additional symbols, which contain DL-MAP and UL MAP (if exist). All other symbols are for data and pilots information. If there is no data only pilots are transmitted. Small part of

operational spectrum is occupied by Pilots and their energy is small, about 2/14 than full energy. On the Preamble symbol, only 1/3 sub channels are occupied, means 1/3 of spectrum is used. The Preamble symbol is boosted by 9 dB/per carrier, above the data, and by 6.5dB, above the pilots. Note: the output power is measured on the Preamble symbol.

2.4.5. Describe if there are any limitations imposed by the contention protocol on what applications are used (i.e. limitations on Quality of Service).

Answer:

- There is no limitation imposed by the contention protocol on applications or QoS.

2.4.6. Describe how applications or configuration of services can affect spectrum usage. To describe your occupancy sharing capability you can assume that two systems on a co-channel are the same (your systems being described). How would they share the spectrum?

Answer:

- The master's scheduler will schedule the sessions according to several criteria. Among others, the required level of QoS, per each session, priority, utilization of the resources in each frame, Channel condition of each client, in UL transmission, etc. This mechanism is used, to maximize air interface resource usage, to minimize power consumption and transmission power and maximize cell range coverage. The system, which will occupy the spectrum, first, will cause the other system to look for clean spectrum. Nevertheless, the system allows fair opportunity, to other system, to use the current spectrum, as described above, in paragraph 2.2.1.

3. Procedures for Permit-but-Ask approvals

Applications for equipment based on restricted contention based protocol can be approved by a TCB following the permit-but-ask procedure. An initial inquiry providing the information described in Section 1 above must be submitted to the FCC for review. Once approved, a TCB may file for final approval once the rest of the application has been reviewed for compliance. The TCB is responsible for ensuring a complete review of the application for compliance with all the relevant requirements.

Special note must be made about the power limits specified in the rules for these devices. These devices are subject to transmitted power[1] and power density limits. Also, mobile devices may have to meet special restrictions based on the mode of operation. The grant must also list the note code RS[2] to denote "restricted contention based protocol".

Change Notice:

4. **1/13/2010 552295** D01 CBT Guidance for 3650 3700 Band v01 has been changed to 552295 D01 CBT Guidance for 3650 3700 Band v01r01 to correct an error. Section 3 -Procedures for Permit-but-Ask approvals – the first sentence was correct from unrestricted to the restricted based protocol.

1 Grant comments "Output is EIRP".

2RS Note Code: This device incorporates a restricted contention based protocol. It is not capable of avoiding co frequency interference with devices using all other types of contention-based protocols. Operation is restricted to the 3650-3675 MHz band.

Appendix A: Contention Based Test – Conducted test

The following figure shows the conducted test setup, for testing the base-station interference threshold detection (BST – Unit Under Test). To establish a WiMax link, the test uses BST and CPE (Customer Premises Equipment). The CPE is Runcom's CPE (Runcom's remote terminal). Both BST and CPE are operating in normal operational mode. The BST is transmitting control and traffic, in downlink direction, at constant power. In parallel, BST is receiving, from CPE, the control and traffic, in uplink direction.

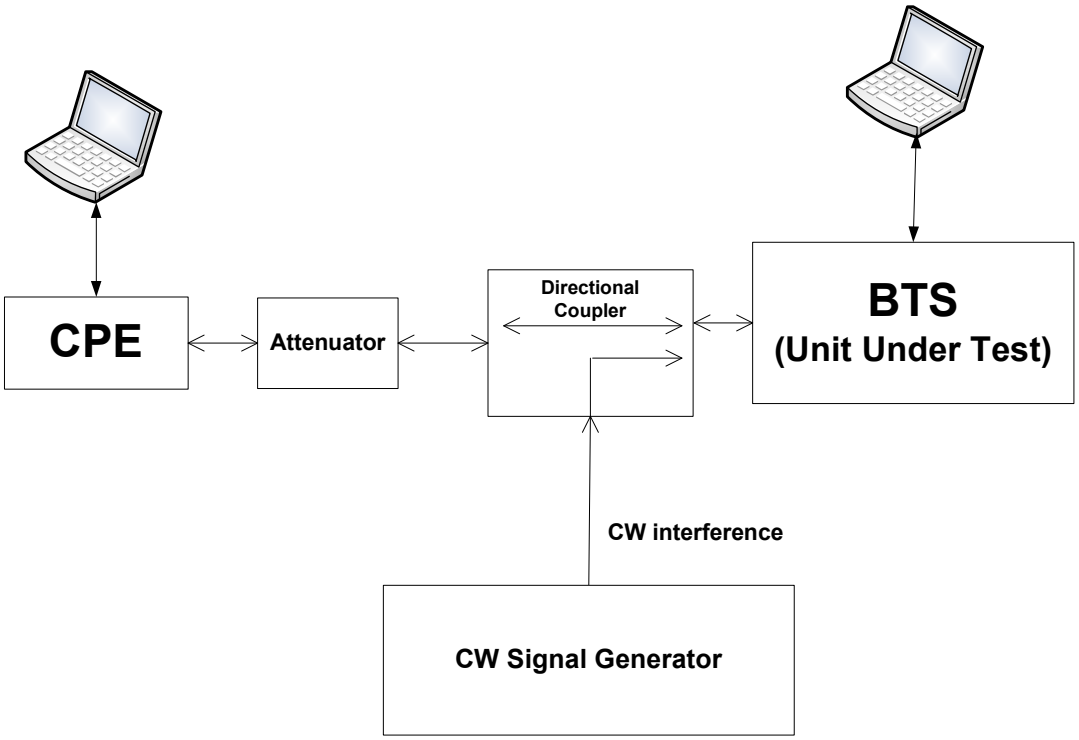

Figure 1: Contention Based interference detection test setup

CW signal is coupled to the uplink WiMax signal. The setup tests the behavior of the BST, as a result of the frequency and the level, of the injected CW signal (interfering signal). When BST detects the CW signal and considers it as interfering signal, it remarks the existing frequency as interrupted frequency. Each test starts with CW signal level 10 dB, below the configured threshold. The level is increased, in 0.1dB steps, until interference detection is reached.

Measurements have been defined over the range of the configured interfering level detection:
Four points have been chosen in the range: -92dBm, -82dBm, -72dBm and -62dBm.
The measurements have been performed in five frequency points:

1. Outside and below occupied BW (Fc-0.6BW)
2. Inside at low and of occupied BW (Fc-0.4BW)
3. Inside at the middle of occupied BW (Fc+0.01BW)
4. Inside at high end of occupied BW (Fc+0.4BW)
5. Outside and above occupied BW (Fc+0.6BW)

The chosen Fc was the mid range of the unrestricted band = 3687.5MHz
Tests have been performed in two types of channel bandwidths: 10MHz and 5MHz.

The following tables show the detection results of different frequencies and power levels.

Configured Threshold	Fc-0.6BW Out-of-band	Fc-0.4BW In-band	Fc+0.1BW In-band	Fc+0.4BW In-band	Fc+0.6BW Out-of-band
-92dBm	-89.4 No	-92.8 Yes	-92.4 Yes	-92.8 Yes	-88.9 No
-82dBm	-79.6 No	-82.7 Yes	-82.5 Yes	-82.5 Yes	-79.6 No
-72dBm	-69.3 No	-72.6 Yes	-72.2 Yes	-72.4 Yes	-69.2 No
-62dBm	-59.4 No	-62.7 Yes	-62.3 Yes	-62.5 Yes	-59.6 No

Table 1: Test results @10MHz BW

Configured Threshold	Fc-0.6BW Out-of-band	Fc-0.4BW In-band	Fc+0.1BW In-band	Fc+0.4BW In-band	Fc+0.6BW Out-of-band
-92dBm	-89.1 No	-92.4 Yes	-92.3 Yes	-92.8 Yes	-89.1 No
-82dBm	-79.9 No	-82.6 Yes	-82.5 Yes	-82.4 Yes	-80.2 No
-72dBm	-69.4 No	-72.4 Yes	-72.4 Yes	-72.6 Yes	-69.5 No
-62dBm	-59.0 No	-62.6 Yes	-62.6 Yes	-62.4 Yes	-59.3 No

Table 2: Test results @5MHz BW

Notes:

1. "Yes" means contention was detected –BST and CPE stops transmitting at the Fc frequency. "No" means contention was not detected - BST and CPE keeps transmitting at Fc frequency.
2. The test setup contains Runcom's CPE, which is not certified by FCC, yet.
3. The BST under test FCC ID is: XYMPICO4A351WDC.
4. Details of equipments:
   - 4.1. CW Signal Generator: Agilent P/N: E4438C S/N: MY42082979
   - 4.2. Directional Coupler: M/A-COM P/N: 2025-6006-10