RADWIN

Office of Engineering Technology
Federal Communications Commission
7435 Oakland Mills Road
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Subject: Unrestricted Contention Based Protocol for RADWIN 2000 JET, RADWIN 5000 JET

To whom it may concern

RADWIN Ltd. wishes to market the RADWIN 2000 JET and RADWIN 5000 JET radio devices operating in the frequency band 3.650 - 3.700 GHz and complying with FCC Rule 47CFR, Part 90 Subpart Z.

RADWIN 2000 JET devices are for point-to-point radio links, consisting of two radio units, one at each end of the link, enabling wireless connectivity for either urban or rural deployments, supporting both access and backhaul applications, providing Ethernet and TDM data interfaces.

RADWIN 5000 JET devices are for point to multi-point systems consisting one base station and several client units (CPEs), enabling wireless connectivity for either urban or rural deployments, supporting both access and backhaul applications, providing Ethernet data interfaces.

The RADWIN 2000 JET and RADWIN 5000 JET radio links use the RADWIN TDD air protocol that meets the FCC definition of an “unrestricted” contention based protocol capable of avoiding co-frequency interference with devices using other types of contention-based protocols, by incorporating the mechanisms described in the following sections.

RADWIN

1. *Definitions*

The definitions used within the RADWIN unrestricted protocol algorithm are detailed in this section:

a. **Radio Frame** – Consists of radio transmit and receive portions with a total duration of 1.25 msec.

b. **Transmit frame** – is the transmit portion of a radio frame. The transmit/receive portions can vary.

c. **TDM Cycle** – A RADWIN basic cycle consists of 64 Radio Frames.

d. **Co-Channel User** - A neighboring communication system that operates in a full or partial overlapping channel with the RADWIN system and its received signal strength is strong enough to generate a detected event at the RADWIN system receiver

e. **Co-Channel User Detection Window (DW)** - A sliding window consisting of consecutive radio transmit frames used to determine whether a Co-Channel User exists and should be considered by the RADWIN system algorithm

f. **Contention Slot** - A set of consecutive transmit frames during which the system must not transmit so as to allow a co-channel user to freely utilize the spectrum media.

g. **Minimum Contention Slot Length** – An equipment constant reflecting the number of consecutive transmit frames unconditionally granted to the co-channel user as defined by the equipment user.
The default value of the Minimum Contention Slot Length is of 8 transmit frames (equivalent to 10 milliseconds) with a range of 4-16 transmit frames (equivalent to 5 – 20 milliseconds)

h. **Total Contention Slot Length** – The sum of all the Contention Slots that may be generated from the TDM cycle based on the "Sharing Percentage" equipment constant.

i. **Sharing Percentage** – An equipment constant that reflects the required spectrum sharing proportion as defined by the RADWIN system user. The default value of the Sharing Percentage is 50% by default and has a range from 15% to75% by resolution step of 5%.
The Sharing Percentage operation is only activated during an occupancy detection scenario.

2. *Unrestricted Protocol Description (Item 2.1 in KDB 552295)*

This section addresses -

- The key requirements for operation using an unrestricted contention based protocol for recognizing other systems (both similar to RADWIN and different from RADWIN) operating on a co-channel.
- The strategy for sharing the spectrum by using spectrum sensing to determine if other devices are transmitting and the method used to share the bandwidth under co-channel occupancy

Here are the main principles of the RADWIN unrestricted protocol:

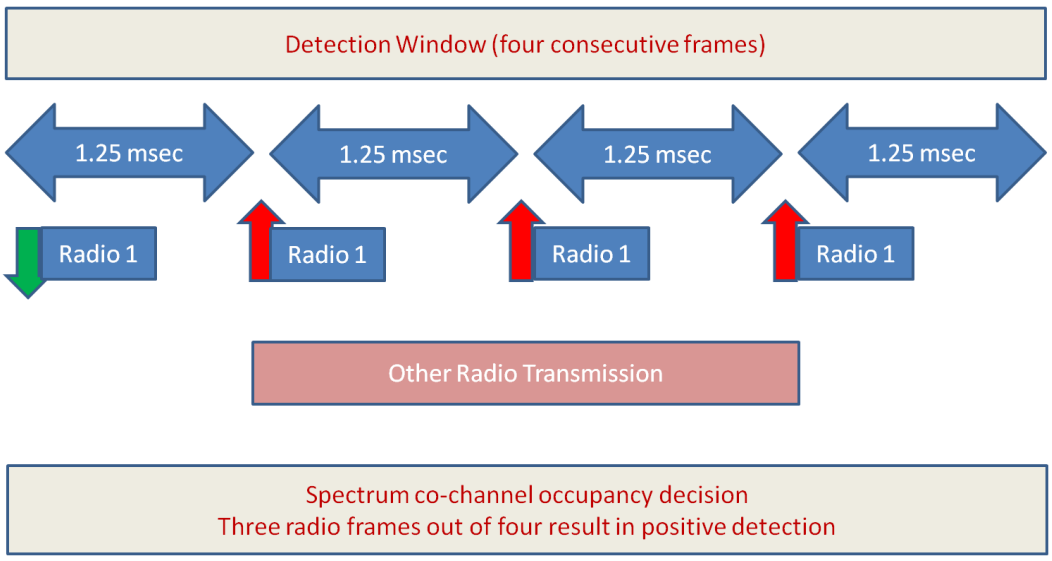
i. The RADWIN device employs a “listen before transmit” function whose purpose is to detect co-channel transmissions above a detection threshold

ii. The detection circuitry measures power level irrespective of the transmitting system’s air interface type

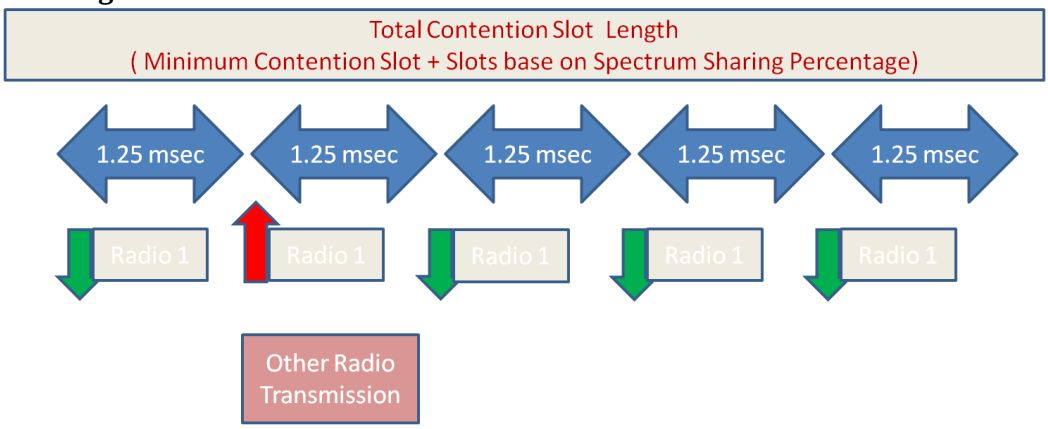
iii. The operating channel is periodically sensed to detect and determine if there are other devices similar to the RADWIN air interface protocol or others transmitting in a co-channel
iv. Carrier sensing for co-channel transmission detection is carried out at the start of each RADWIN transmit frame (every 1.25 msec)
v. A co-channel user sliding window named as "Detection Window" (DW), composed of four consecutive RADWIN transmit frames (equivalent to 5 milliseconds), is used to determine whether a co-channel user exists
vi. Every four consecutive RADWIN transmit frames (DW) (equivalent to 5 milliseconds), the RADWIN system checks if a co-channel transmission was detected in each transmit frame.
vii. Upon detection of co-channel occupancy in three out of the four consecutive transmitted frames, the system cancels the next planned transmit frames to enable sharing the bandwidth in the same channel with other transmitting devices
viii. The number of the canceled transmit frames is defined by the Contention Slot threshold
ix. The Contention Slot attribute defines the consecutive transmit frames during which the system may not transmit so as to allow a co-channel user to freely utilize the channel spectrum
x. The "Contention Slot" is defined as follows:
    a. **Minimum Contention Slot Length**
    b. **Total Contention Slot Length**.

The following two diagrams illustrate the RADWIN mechanism of carrier sensing, co-channel detection and occupancy action:

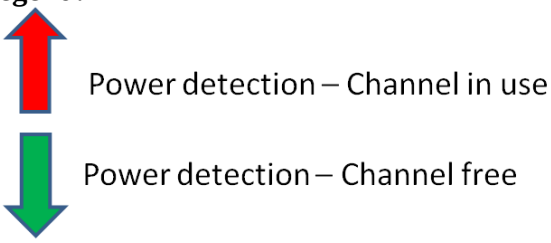
Drawing 1:



Drawing 2:



Legend:



3. Threshold detection to determine occupancy (Item 2.2 in KDB 552295)

Q. 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?

A. The RADWIN device radio design includes circuitry for performing in-band interference measurement. The power detection level for co-channel occupancy is -85 dBm relative to 0 dBi receive antenna gain.

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

A. The system observes the channel during a period of at least 50 µsec (depending on how much data is transmitted in current radio frame) every 1.25 msec (transmission frame) for at least four consecutive transmission frames (Detection Window, equivalent to 5 milliseconds) to determine if the channel is busy.

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

A. The bandwidth monitored for co-channel occupancy is equal to the system operating channel bandwidth.

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

A. The system operator has the variability to change the DW in the range of 4-16 transmit frames (equivalent from 5 – 20 milliseconds). There is an equipment constant reflecting the required spectrum sharing proportion which is defined by the system operator. It has the variability to be changed in the range of 15% to 75% by resolution steps of 5%.

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

A. The operating system threshold (receive threshold) has a dynamic detection range from -65dBm down to -96dBm whereas the monitoring threshold is -85 dBm in all operating channel bandwidths.

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

A. None

Q. Does 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)?

A. Both master and client perform the threshold detection.

4. Action taken when occupancy is determined (Item 2.3 in KDB 552295)

Q. 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?

A. Upon detection of occupancy in at least three out of four consecutive transmitted frames, the system cancels the next planned transmit frames**.** The number of the cancelled transmit frames is determined by the Contention Slot threshold, which is defined by the Minimum Contention Slot Length and the Total Contention Slot length.
Transmission will start again only when all transmission frames, that were determined to be cancelled from transmission, were transferred for use to the co-channel user.
Example: Assuming a system with an operation period of 80 msec (64 transmit frames of 1.250msec) during which occupancy was detected, under a Sharing Percentage of 50% defined by user, the number of cancelled transmission frames will be $\frac{80}{1.25} \times \frac{1}{2} = 32$.
In case of concurrent carriers detecting co-channel occupancy and the system cannot provide the required service to the operator, the system will reach sync loss threshold, and will evacuate the specific operating channel.
The system sync loss threshold criteria for abandoning the operating channel is 60% PER in the lowest rate (13Mbps of QPSK modulation with FEC 1/2).
The traffic rate has no impact on the performance of the spectrum sensing and transmission avoidance performance.
The service quality and traffic performance are affected under co-channel occupancy detection and are dependent upon the detection rate and the spectrum Sharing Percentage defined by the system user.

Q. 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.

A. None

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

A. No such mechanism as both master and client use the same occupancy detection mechanism.

5. *The opportunities for other transmitters to operate (Item 2.4 in KDB 552295)*

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

A. The system activates the same mechanism in all system states including "start-up acquisition" and operational mode.

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

A. In operational mode the system will stop transmitting after detecting occupancy within at least three out of four transmission frames (5 msec).

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

A. The system listens prior to every transmission during a period of at least 50 µsec (depending on how much data is transmitted in current radio frame) within each 1.25 msec radio frame.

Q. Describe how the operational spectrum usage (on air time) is dependent 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.

A. The system activates the same mechanism under any system load condition. When there is no information to transmit the system will still perform spectrum sensing to continuously evaluate any co-channel occupancy.

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

A. There are no limitations imposed by the system. When sharing channel occupancy, system capacity will be reduced according to the spectrum Sharing Percentage. In this case, the system scheduler will prioritize traffic (based on packet classification rules) accordingly.

Q. 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?

A. The system enables the collocation of more than one RADWIN radio and minimizes their co-channel spectrum sharing, by ensuring that –

- Each system will only transmit when it has detected that the channel is clear according the pre-defined Contention Slot length

- If one system is transmitting, the second system will be able to transmit when the data transfer on the first system is complete
- With evenly loaded systems under an even spectrum Sharing Percentage, the opportunities to transmit will statistically be equal for each radio
- The "listen before transmit" mechanism combined with aligned Contention Slot Length and Sharing Percentage values, minimizes interference between systems, reducing the need for re-transmissions and maximizing overall spectrum efficiency
- RADWIN also uses a propriety synchronization mechanism that synchronizes transmit and receive paths for more than one radio minimizing the mutual-interferences.

6. *User configuration*

The user is allowed to configure two equipment constants for the contention protocol algorithm:

a. **Minimum Contention Slot Length** – Reflects the number of consecutive transmit frames that are unconditionally granted to the co-channel user and is defined by the user The factory setting of the Minimum Contention Slot Length is 8 transmit frames (equivalent to 10 milliseconds) with range from 4-16 transmit frames (equivalent from 5 – 20 milliseconds).

b. **Sharing Percentage** – An equipment constant reflecting the required spectrum sharing proportion as defined by the user. The default value of the Sharing Percentage is 50% by default and has a range from 15% to 75% by resolution step of 5%.

The RADWIN system user must have a user installer authorization access in the Management System in order to configure the above equipment constants.

With the implementation of the above mechanisms RADWIN radio links enable a reasonable opportunity to operate in a co-channel under unrestricted mode.

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