Unrestricted Contention-based Protocol

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Revision History

Document Revision History

Version	Description of Change	Author	Date
0.1	Initial version.	Andi	September 28th, 2012
0.2	Updated version.	Andi	October 1st, 2012
0.3	Updated for 552295 D01 “CBP Guidance for 3650 3700 Band v02r02”	Greg	May 14th, 2013

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1 Introduction

1.1 Overview

The Unrestricted Contention-based Protocol implemented in release 1.1 complies with the FCC requirements for 3.65 – 3.7 GHz band. This feature allows the X100 systems to share the same (unlicensed) radio channel with other wireless communication devices. The protocol is based on a collision-avoidance mechanism similar to CSMA/CA (Carrier Sense Multiple Access with Collision Avoidance) used in 802.11. The rule of CBP is to listen before any attempt to transmit over the air and defer the transmission if the interference level exceeds a certain threshold.

1.2 Definitions and Terms

CBP	Contention-based protocol
TTG	Transmit transition gap
RTG	Receive transition gap
UL	Uplink
DL	Downlink
PA	Power amplifier
DAN	DesignArt Networks
OFDM	Orthogonal Frequency Division Multiplexing
CW	Continuous wave
WiMAX	Worldwide Interoperability for Microwave Access

2 Implementation details

The HUB performs a channel measurement over 128 samples every frame, during the RTG. If the level of the interference exceeds the CBP threshold, then the HUB turns the Power Amplifier off before the beginning of the next wireless frame, and defers the transmission of the DL OFDM burst over the air.

The picture below shows the normal TX/RX cycle of the RF front end. Every wireless frame, the transceiver is turned into TX mode during the RTG, before the beginning of the next DL sub-frame. After the downlink burst is transmitted over the air, the RF front end is switched back into the RX mode.

When the interference is detected, the transmitter is switched off on both radio cards. The transmission is resumed after the interference is gone.

Figure 1: The power amplifiers on both radio cards are switched off while the interference exceeds the threshold.

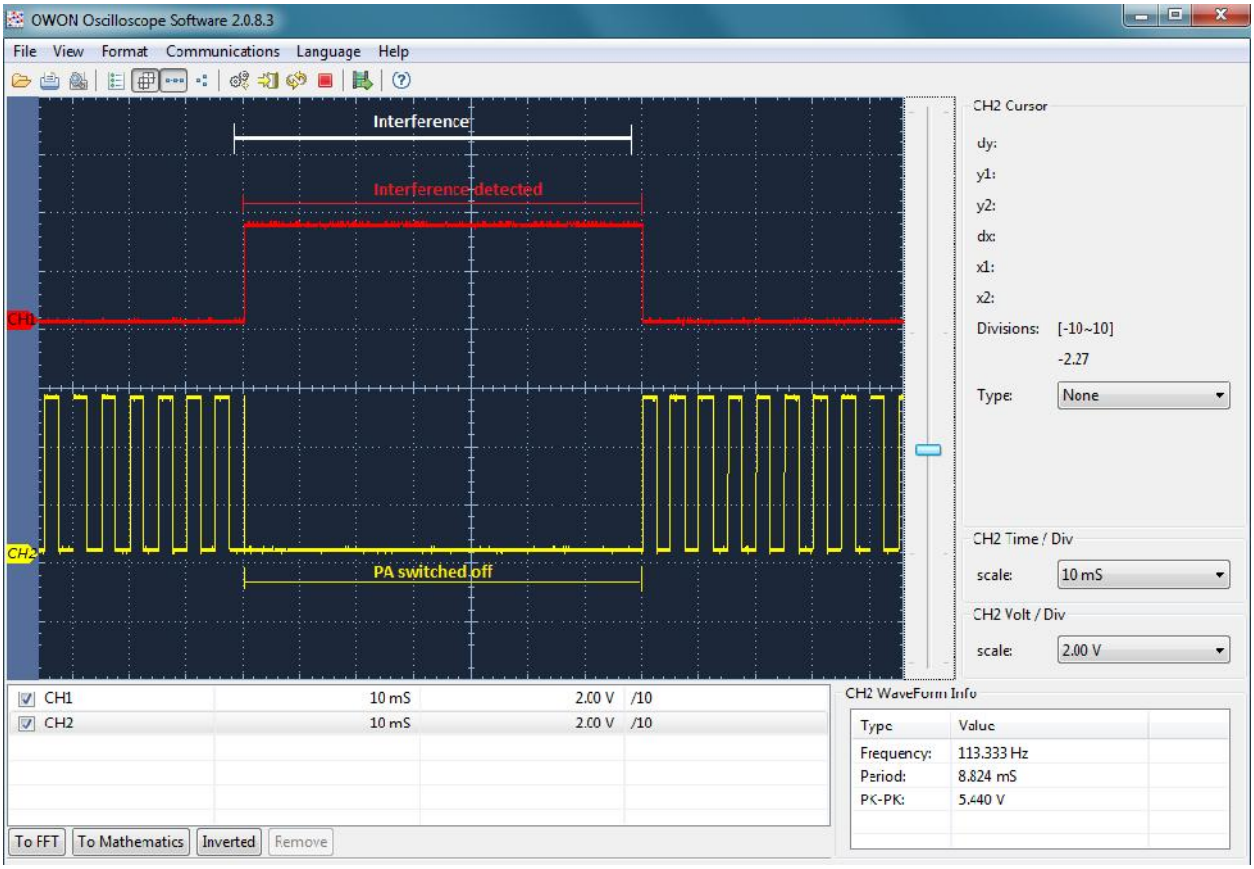


Figure 2: At the time of interference detection the power amplifier is already turned on, to accommodate the ramp-up of the PA (40 microseconds before the TX starts). When the interference is detected, the PA is switched off as soon as possible, before the RF switch is turned into the TX mode.

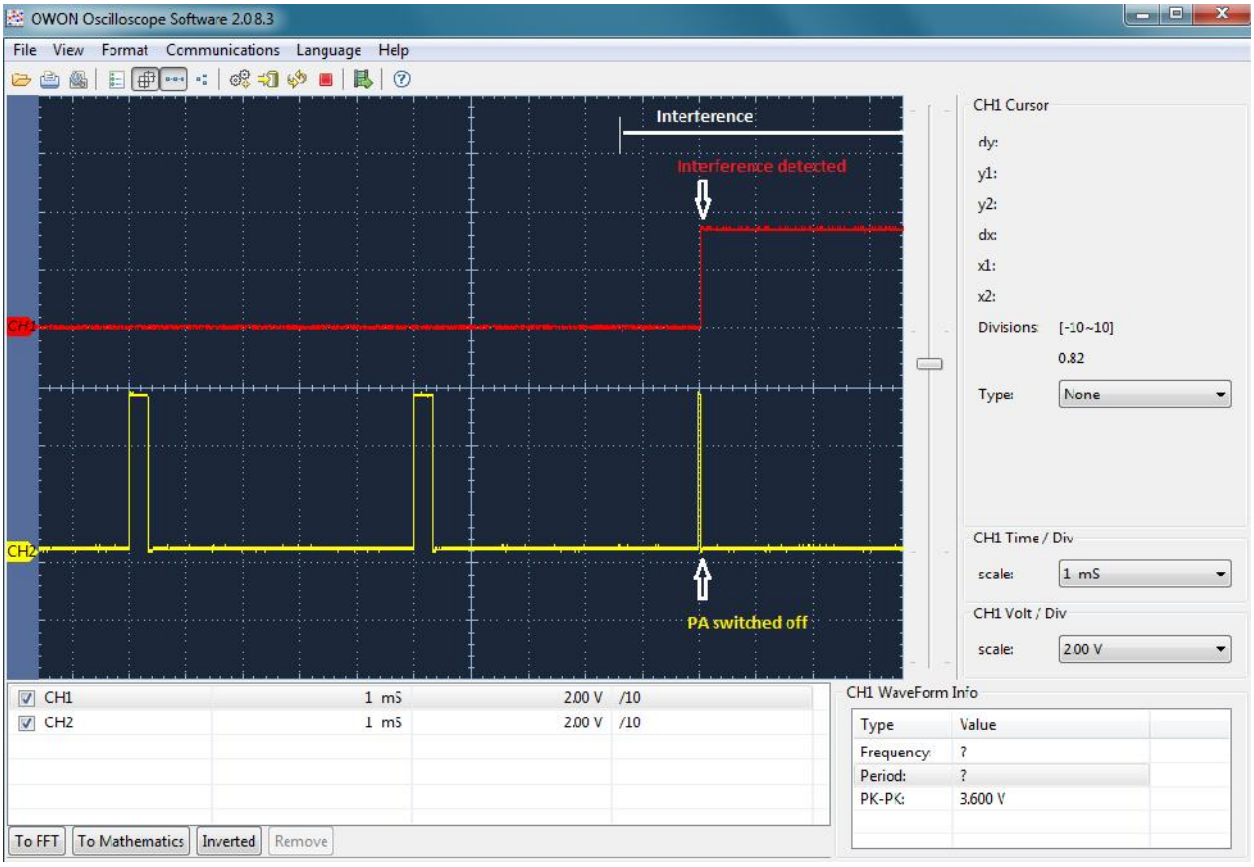
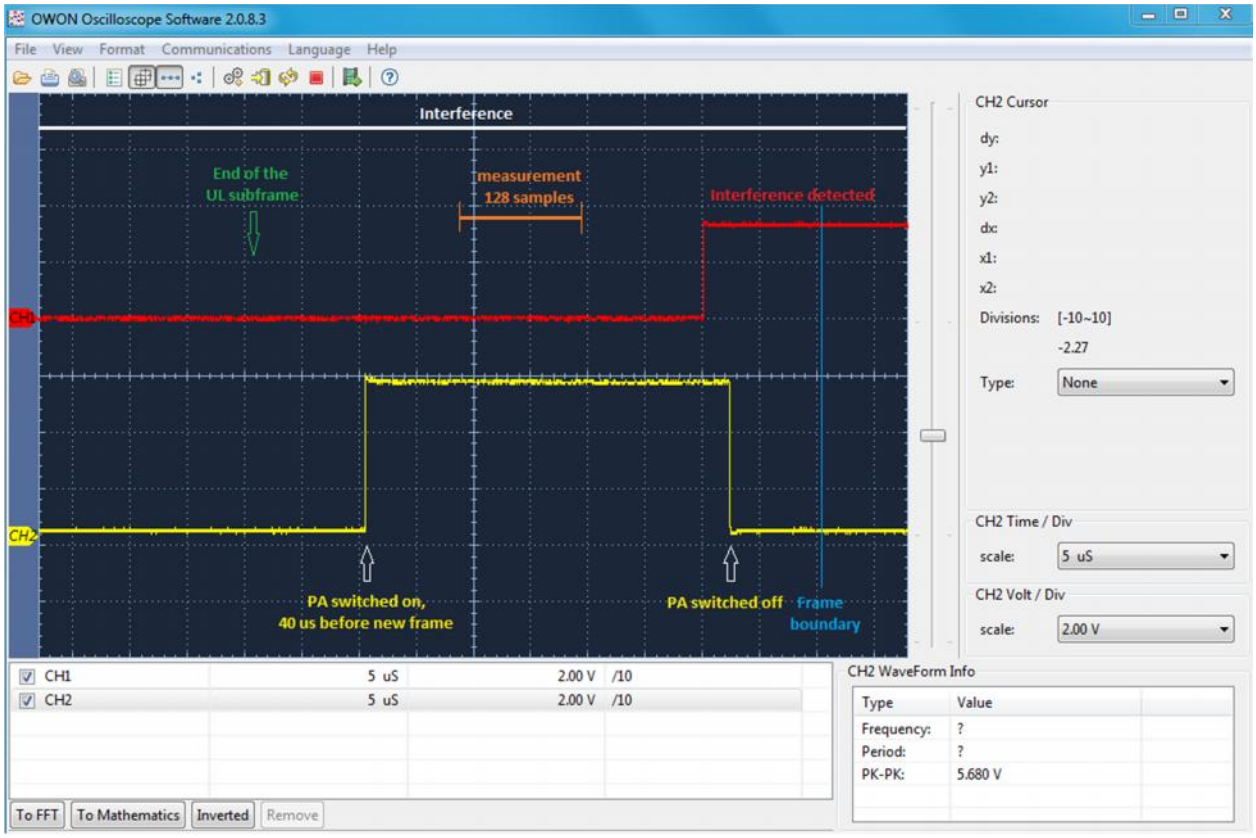


Figure 3: A closer look at the RTG.

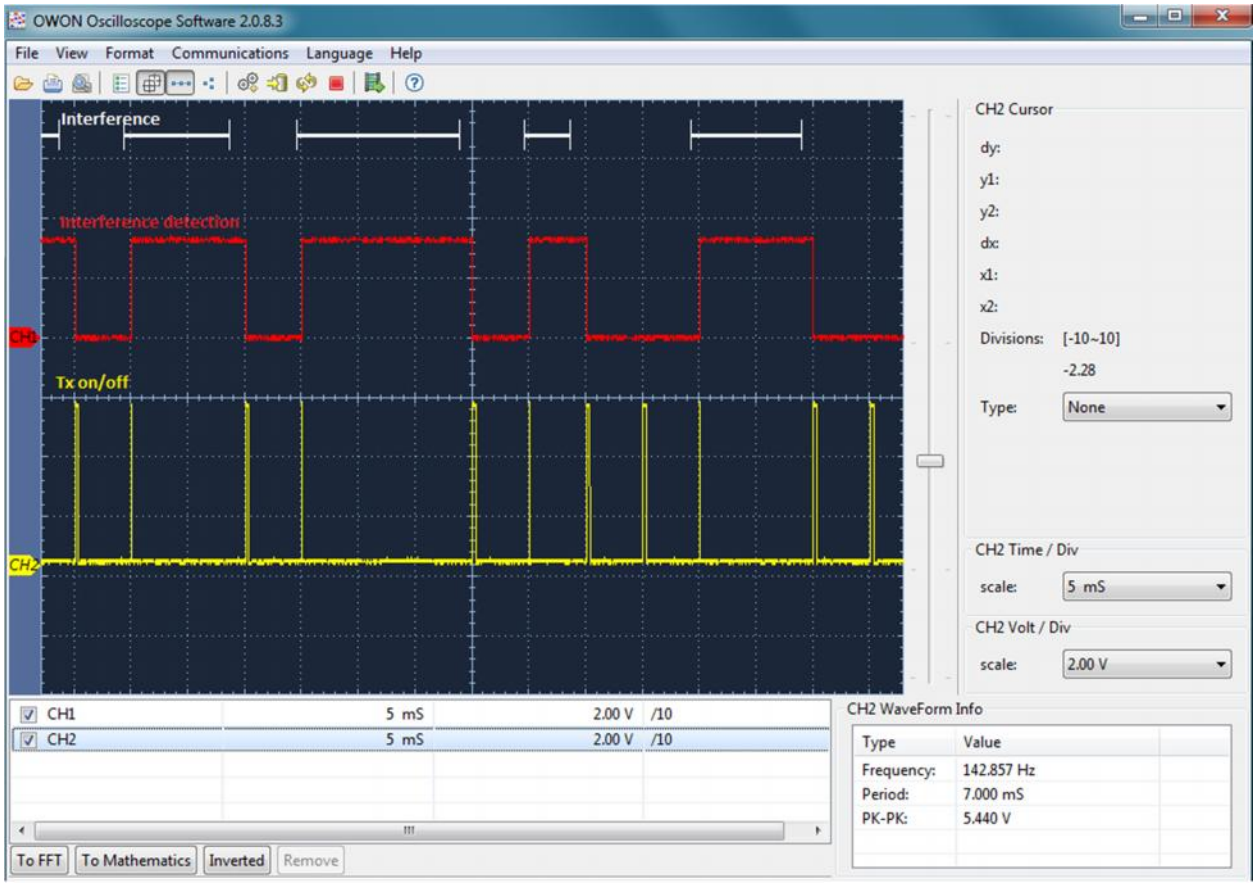
The channel measurement is performed on 128 samples in the middle of the RTG. If the interference level exceeds the threshold, then the power amplifiers are turned off as soon as possible.



At the HUB, the interference measurement is done during the RTG for the following reasons:

- All the X100 clusters (as well as other WiMAX Base Stations) synchronized with the GPS do not transmit during the RTG, thus, a false interference detection caused by frequency reuse of 1 is avoided.
- The channel measurement does not have any impact on the system's capacity.
- The decision whether to transmit or not is made immediately before the beginning of the DL sub-frame.

Figure 4: In the presence of random interference, the X100 HUB collision-avoidance mechanism behaves as follows:

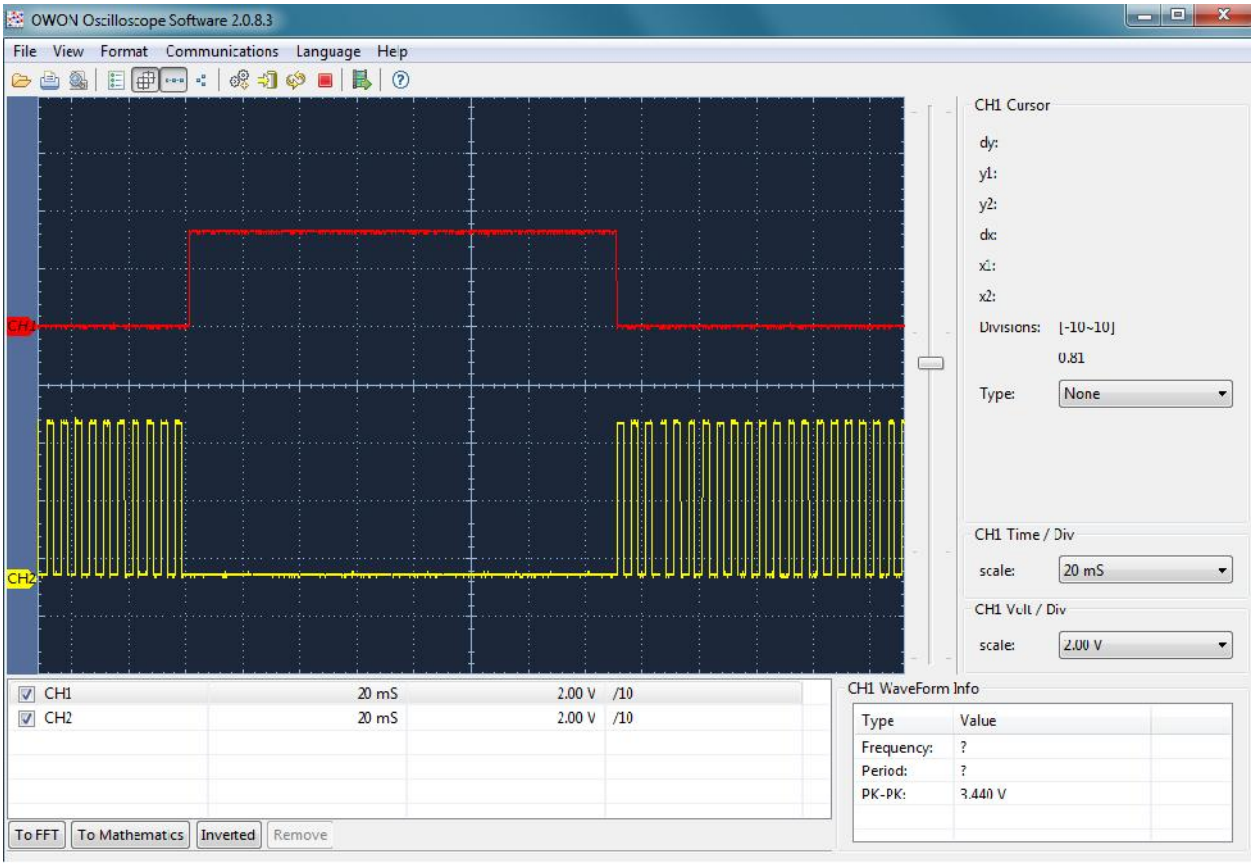


At the RBM, the collision-avoidance mechanism is similar, but the interference measurement is performed in the middle of the TTG.

Observations:

1) The UL-Map transmitted by the HUB in frame N is relevant for frame N+2. Therefore, if the HUB defers its transmission in frame N due to interference, then the RBM will not transmit anything in the uplink sub-frame N+2.
2) When CBP is enabled, an RBM will not transmit during its allocated UL grant, if:
   a. The HUB has not transmitted the UL-Map for this frame, or
   b. The RBM has detected interference during the TTG of the current frame.

Figure 5: At the RBM, the interference is detected before the PA is switched on. When the interference disappears, the RBM transmission can be started in the very next uplink sub-frame, after the TTG.



Observations:

1) If the interference is strong enough to corrupt the MAPs, then the RBM will continue to defer the transmission for two more frames after the interference is gone (see the observations above).
2) In 3.65 - 3.7 GHz band with CBP enabled, the wireless link performance may be highly impacted by interference. In order to minimize the effect of the interference, the X100 system should be able to change the RF channel without interrupting the service.

3 Configuration and status

The CBP threshold parameter can be configured via DAN CLI. The valid range of this parameter is [-96, -30] dBm, and the default value is -30 dBm. When the threshold is set to -30 dBm, the CBP is inactive.

The name of this parameter is **`RF_DRV_cbp_threshold`**, defined as *`the interference threshold [dBm] for CBP activation`*.

The conditions to activate the CBP are the followings:

- The RF channel overlaps with the frequency band [3.65, 3.7] GHz.
- The CBP threshold belongs to [-96, -31] dBm.

When the CBP is activated, the level of the interference measured at each antenna is available via CLI.

Use **`RF_DRV`** CLI command to display the interference level at both antennas, as well as the CBP threshold and a CBP counter:

```
BLINQ_HM>RF_DRV

 RF2 Temperature = 125.0 Celsius
 RF2 Temperature ADC value = 10
 RF2 Temperature = 32 mV

 RF2 Freq PD offset = 0
 RF2 Freq Attn offset = 0
 RF2 Power Detector ADC value = 0
 RF2 Power Detector value = 0 mV
 RF2 Power detector = 0.0 dBm
 RF2 Ref Power = 0.0 dBm
 RF2 Power delta = 0.0 dB
 RF2 Invalid CAL or PD correction disabled

 RF4 Temperature = 125.0 Celsius
 RF4 Temperature ADC value = 3
 RF4 Temperature = 9 mV

 RF4 Freq PD offset = 0
 RF4 Freq Attn offset = 0
 RF4 Power Detector ADC value = 0
 RF4 Power Detector value = 0 mV
 RF4 Power detector = 0.0 dBm
 RF4 Ref Power = 0.0 dBm
 RF4 Power delta = 0.0 dB
```

```
RF4 Invalid CAL or PD correction disabled

Interference level: RF2 -66 dBm, RF4 -72 dBm
CBP:  Thrs -60 dBm, Cnt 43

BLINQ_HM>
```

The CBP counter is incremented every time the transmission is deferred. The channel measurement is done simultaneously at both antenna ports during the RTG (HUB) and TTG (RBM), and the transmission is deferred if the interference level at either antenna exceeds the threshold.

4 Testing and Validation

1) Generate a CW with the specified power and frequency, and verify the CBP behavior. In order to check the interference detection at both antennas, inject the CW into the RF2 port when testing 3655 MHz RF channel, and then inject the CW into the RF4 port when testing 3695 MHz channel.

If the interference exceeds the threshold, then both radios must turn off the transmitters.

Channel Frequency (MHz)	Channel Bandwidth (MHz)	Interferer (CW) Frequency (MHz)	Noise Threshold (dBm)	Interferer (CW) level (dBm)	Expected Results
3655	10	3650	-60	-59, -61	Tx-Off Tx-On
			-65	-64, -66	Tx-Off Tx-On
			-70	-69, -71	Tx-Off Tx-On
		3655	-60	-59, -61	Tx-Off Tx-On
			-65	-64, -66	Tx-Off Tx-On
			-70	-69, -71	Tx-Off Tx-On
		3660	-60	-59, -61	Tx-Off Tx-On
			-65	-64, -66	Tx-Off Tx-On
			-70	-69, -71	Tx-Off Tx-On
3695	10	3690	-60	-59, -61	Tx-Off Tx-On
			-65	-64, -66	Tx-Off Tx-On
			-70	-69, -71	Tx-Off Tx-On
		3695	-60	-59, -61	Tx-Off Tx-On
			-65	-64, -66	Tx-Off Tx-On
			-70	-69, -71	Tx-Off Tx-On
		3700	-60	-59, -61	Tx-Off Tx-On
			-65	-64, -66	Tx-Off Tx-On
			-70	-69, -71	Tx-Off Tx-On

2) Verify the interference measurement accuracy at both the HUB and the RBM, in the presence of another co-channel cluster synchronized with the GPS.

5 552295 D01 CBP Guidance for 3650 3700 Band v02r02 – Unrestricted Certification

This section answers the questions to "FCCs 552295 D01 CBP Guidance for 3650 3700 Band v02r02" section 2, Unrestricted Certification.

Question 2.1) The contention based for the application uses RF energy detection in this radio. This radio (ROR00000001) uses a threshold RF energy detector within the occupied band (-31 to -90 dB) as demonstrated in section 4 Testing and Validation of the Test Report (ROR00000001 Unrestricted Contention Based Protocol).

Question 2.2.1) The collision avoidance mechanism is listen-before-transmit. The busy channel threshold is configurable between -31 and -95 dBm at the RF connector, and the default value is -65dBm. The antenna gain used is 17dBi, therefore the default value RSSI relative to 0dBi is -82dBm.

Question 2.2.2) The measurement takes 11.43 microseconds. The measurement interval ends about 15 microseconds prior to switching the PA on.

Question 2.2.3) The measurement is accurate within the 10MHz channel.

Question 2.2.4) The recommended range for the busy channel threshold is -60 to -90 dBm.

Question 2.2.5) The target received signal strength at the HUB (master) is configurable, with a default value of -65dBm.

Question 2.2.6) The HUB (master) and RBM (client) monitor interference on a frame by frame basis (every 5ms) and only start transmission if interference is not detected.

Question 2.2.7) Both the master and the client listen before transmitting.

Question 2.3.1) The system does not transmit anything in the current wireless frame. The same transmission policy applies on a frame-by-frame basis. If the channel becomes free, then the system resumes the transmission over the air. The CBP is not affected by the amount of data traffic.

Question 2.3.2) Not Applicable

Question 2.3.3) If only the HUB detects occupancy then it does not transmit the frame descriptor (MAP) for the current wireless frame and the RBMs (clients) will not transmit anything in the uplink.

Question 2.4.1) Not Applicable

Question 2.4.2) The transmission could take up to 3.011 milliseconds for 5 ms frame duration and 65/35 DL/UL ratio.

Question 2.4.3) Yes, please see 2.2.6.

Question 2.4.4) Management and link control information.

Question 2.4.5) The system has limited buffering capabilities. Therefore extended periods of contention (no transmission) will result in traffic drops.

Question 2.4.6) The systems are frame synchronized and designed for co-channel operation, as long as enough isolation is provided to meet system CINR requirements.

6 References

[1] FCC-05-56A1.pdf