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Re:	IEEE P802.16-REDd/D2-2003
Abstract	This is an informative text for the discussion for the RSSI measurements
Purpose	The document is contributed to be discussed in IEEE802.16d in the process of comments resolution.
Notice	
Release	
Patent Policy and Procedures	

RSSI Measurements

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Background

IEEE P802.16-REVd/D2-2003 describes two kinds of signal quality measurements, RSSI (receive signal strength indicator) and CINR (carrier-to-interference-and-noise ratio). The document explains one possible method to estimate the CINR but it does not explain the method to estimate the RSSI. Thus, we provide a convenient and accurate method to estimate the RSSI for consistency and completeness of the document.

RSSI Measurement Algorithm

Fig. 1 shows the receiver structure from the receive anenna to the ADC. (analog-to-digital converter)

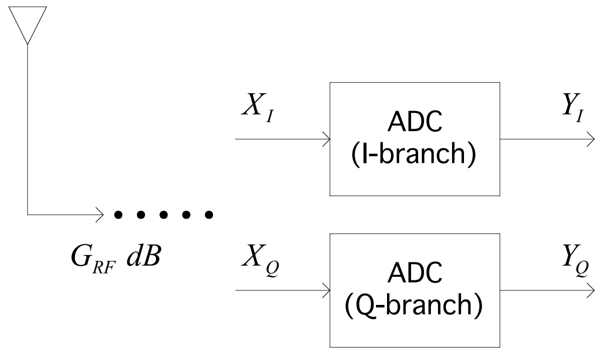

Fig. 1: Receiver structure from the receive antenna to the ADCs

It is possible to estimate the RSSI at the output of ADC. The probability density functions at the inputs of ADCs and the outputs of ADCs are approximately Gaussian with zero mean. So the following expressions can be satisfied

$$\sigma_{X_I}^2 = \sigma_{X_Q}^2 = \sigma_X^2 \text{ and } \sigma_{Y_I}^2 = \sigma_{Y_Q}^2 = \sigma_Y^2 .$$

The input power to the ADCs is given by

$$P_{in,ADC} = \frac{\sigma_{X_I}^2}{R} + \frac{\sigma_{X_Q}^2}{R} = \frac{2\sigma_X^2}{R} \text{ Watt}$$

where R is the input resistance of ADC.

If we assume the number of bits and the input clip level of the ADC to be B and V_c respectively, then the relationship between σ_X^2 and σ_Y^2 is $\sigma_Y^2 = k^2\sigma_X^2$ where $k = \frac{2^{B-1}}{V_c}$.

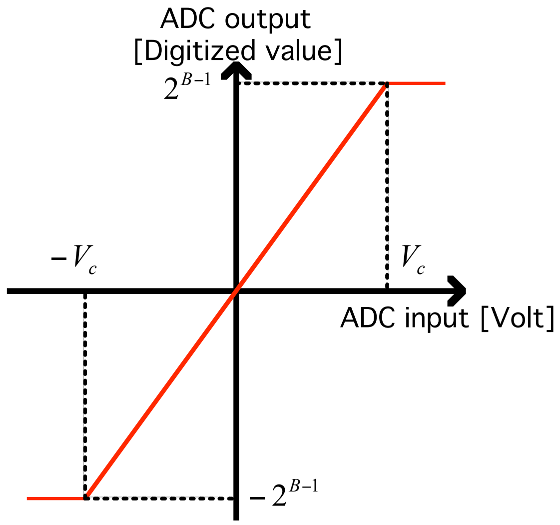

Fig. 2: The input/output relationship of ADC

For zero mean Gaussian random variable Z , is is satisfied that (See Appendix A)
$E^2\{|Z|\} = 0.6366\sigma_Z^2$.

Thus, the power at the ADC can be calculated by

$$P_{in,ADC} = \frac{2\sigma_X^2}{R} = \frac{2\sigma_Y^2}{k^2 R} = \frac{2E^2\{|Y|\}}{0.6366k^2 R} = \frac{8V_c^2 E^2\{|Y|\}}{0.6366\left(2^{2B}\right)R} \text{ Watt}$$

where $E\{|Y_I|\} = E\{|Y_Q|\} = E\{|Y|\}$

Thus, the RSSI at the antenna connection can be given by

$$RSSI = 10^{-\frac{G_{rf}}{10}} \frac{1.2567\times 10^4 V_c^2}{\left(2^{2B}\right)R}\left(\frac{1}{N}\sum_{n=0}^{N-1}\left|Y_{I\text{ or }Q}[k,n]\right|\right)^2 \text{ mWatt}$$

where $Y_{I\text{ or }Q}[k,n]$ is the n th sample at the ADC output of I or Q-branch within signal k and G_{rf} is the analog gain from antenna connector to ADC input.

Fig. 3 is all the required hardware to estimate RSSI according to the discussed algorithm.

ADC (I or Q-branch) → ABS → Accumulator

Fig. 3: Required hardware to estimate RSSI

Proposed Changes

[add the following to sections 8.4.11.2 at the end of line #38]

One possible method to estimate the RSSI of a single signal at the antenna connector is given by

$$RSSI = 10^{-\frac{G_{rf}}{10}} \frac{1.2567\times 10^4 V_c^2}{\left(2^{2B}\right)R}\left(\frac{1}{N}\sum_{n=0}^{N-1}\left|Y_{I\text{ or }Q}[k,n]\right|\right)^2 \text{ mWatt}$$

where

B	ADC precision, number of bits of ADC
R	ADC input resistance [Ohm]
V_c	ADC input clip level [Volts]
G_{rf}	Analog gain from antenna connector to ADC input
$Y_{I\text{ or }Q}[k,n]$	n th sample at the ADC output of I or Q-branch within signal k

Appendix A

For the Gaussian random variable Z , the probability density function for Z is given by

$$f_Z(z) = \frac{1}{\sqrt{2\pi\sigma^2}}\exp\left[-\frac{(z-m)^2}{2\sigma^2}\right]$$

where σ is the standard deviation and m is the mean.

Since $E\{|Z-m|\} = \sqrt{\frac{2}{\pi}}\sigma$, $E^2\{|Z|\} = \frac{2}{\pi}\sigma^2 = 0.6366\sigma^2$.