Mechanisms for measuring output power and power spectral density of a transmitter in a WiMAX radio network

Assoc. Prof. Pasarelski R. [1], M.Sc. eng. Teodora Ivanova[2], M.Sc. eng. Dobrev Ts. [2]
Department of Telecommunications – New Bulgarian University , Sofia, Bulgaria
rpasarelski@nbu.bg; tpasarelska@mtitc.government.bg

Abstract: *The report examines current problem in wireless WiMAX networks, namely the possible ways and mechanisms to measure the output power and power spectral density of radio transmitter. The purpose of measurement is to determine the maximum output power of the transmitter is within the manufacturer's declared value with a certain tolerance set by EN / ETS and does not exceed the maximum limits. Also to measure or calculate the power spectral density of radiated power in the frequency channel with a specific width. The following parameters must be measured in full and coordinated load of the transmitter. These are the key parameters needed to research for the effective design of broadband WiMAX wireless data system.*

Keywords: WIMAX, MEASUREMENT, POWER, SPECTRAL DENSITY, RADIO TRANSMITTER.

Introduction

In a study of wireless networks for data broadcasting are considered and measure key parameters to evaluate the technical condition of the radio network.

Measurements of the parameters of transceiver equipment are divided into two types:

A) Measurements in the transmission part

- Transmitting power;
- Spectral mask of radiation;
- Signal level at any point of the coverage area;
- Side lobes in the transmitter;
- Instability of the frequency of the transmitter;
- Automatic power control of the transmitter;
- Remote control transmitter power;
- Automatic control of the frequency of the transmitter.

B) Measurements in the receiving section

- Receiver sensitivity;
- Resistance to interference in the same and adjacent channel;
- Side lobes in the receiver;
- Ratio of digital error (Bit Error Ratio, BER) as a function of the input signal.

To the listed parameters in the transmitting and receiving part can make the following clarifications:

The output power of the transmitter is measured as the transmitter is loaded with coherent load instead antenna system. Defines the minimum and maximum output power and the manufacturer of the equipment must be specifically asked the acceptable range of change of power.

Signal level at a point of the coverage area is measured to determine the power spectral density where it is needed. This measurement is required by the standards set in the license for "point-to-multipoint" wireless broadband data systems.

1. Parameters to measure

Manufacturer must declare the maximum rated output power for every base station. Have to be declared and the number of carrier frequencies N (respectively transceivers) to the base station, each of which can be modulated with the maximum speed of the digital stream at the same modulation scheme. The following parameters must be measured in full load of the transmitter. Each carrier, modulated with a specific modulation should broadcast signal power equal to 1 / N of the maximum rated power declared by the manufacturer. The transmission capacity of the base station should be divided equally between carriers.

1.1. Output power of the transmitter

Definition: The average power measured when the transmitter output is connected to the coherent absorbing load or antenna (with directional coupler - if you have access to output). The measurement is performed with a power meter or spectrum analyzer.

Objective measurement: To establish that the maximum output power of the transmitter is within the declared of the manufacturer value ± a certain tolerance (set by EN / ETS) and does not exceed the maximum limits set by EN / ETS.

Standard of the measurement: The measured maximum power at point must not exceed 35 dBm according to standards EN 301 021 and EN 301 080 of ETSI. The tolerance of this value for point-to-multipoint systems operating at frequencies below 11 GHz is ± 2 dB according to EN 302326-2.

Measuring staging:

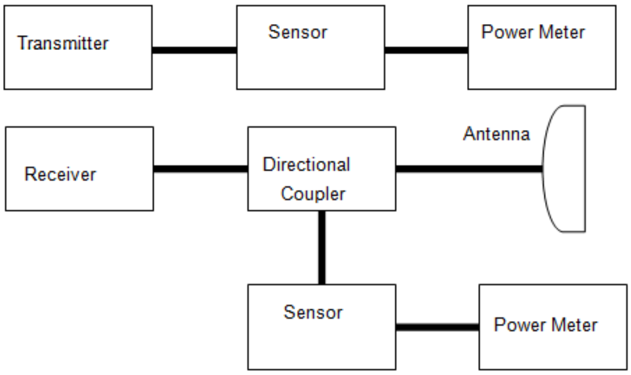

Fig. 1. *Measuring staging for determination of output power of the transmitter*

Measuring procedure:

a) FDD mode

1) The carrier frequency of the transmitter modulates with a signal representing normal traffic situation under conditions of traffic load and services.

2) The power level of the transmitter is set to the maximum possible value (with switched on Automatic Transmit Power Control - ATPC).

3) Measure the average value of the power

b) TDD mode

1) By attenuator the output power of the transmitter is fed to a diode detector (the measuring probe), which represents the measuring sensor head of the power meter.

2) The combination of detector measuring sensor and the power meter must be able to reproduce faithfully the duty cycle of the signal, which represents the period of time - Tx_{on}, in which the transmitter radiates to the overall period of time - $Tx_{on} / (Tx_{on}+Tx_{off})$, which includes the period when signal is not radiating. The observed segment of the operating cycle is marked by x, where $0 < x \leq 1$.

3) The maximum output power of the transmitter is defined using a broadband combined spectral analyzer with a coherent detector with thermocouple. The measured value is indicated by A.

4) The maximum Equivalent Isotropic Radiated Power (EIRP) is calculated by using x and A according to the formula:

$$EIRP\ [dBm] = A\ [dBm] + 10lg\ (1/x),$$

and when it is necessary to obtain EIRP after transmitting antenna with gain - G, is worked by the formula:

$$EIRP\ [dBm] = A\ [dBm] + G\ [dBi] + 10lg\ (1/x).$$

1.2. Power Spectral Density

Power spectral density (PSD) is a parameter that allows comparing power levels of the frequency transmit channel with different bandwidth.

Definition: The power level at a point, normalized to the channel with a single specific bandwidth. As the WiMAX "point-to-multipoint" systems the bandwidth of the transmit channels is measured in MHz, then the power spectral density is normalized to a bandwidth of 1 MHz.

Objective measurement: To measure and / or calculate the power spectral density of radiated power in the frequency channel with a specific bandwidth.

Standard of the measurement: For broadband "point to multipoint" systems in the 3.5 GHz, the standards for power spectral density are presented in Appendix 2 to the individual license of "point to multipoint" systems. For systems that use unlicensed frequency band 5.8 GHz, General License № 220 defines the following technical specifications as standards for EIRP and power spectral density:

Table 1. *Technical specifications for EIRP and power spectral density*

Channel bandwidth	Maximum average power at the antenna input, dBm	Maximum EIRP, dBm	Maximum average spectral density of EIRP, dBm/MHz
10 MHz	27	33	23
20 MHz	30	36	23

Measuring staging:

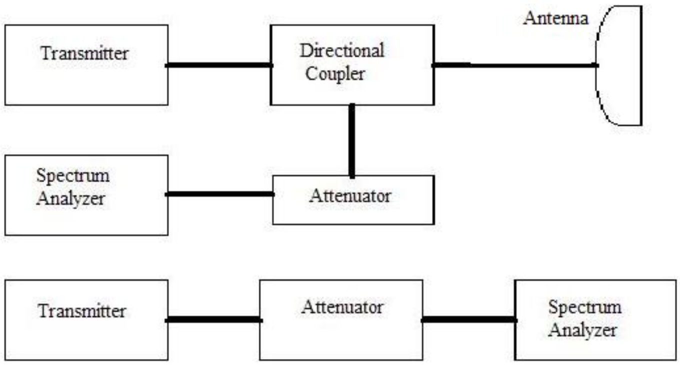

Fig. 2. *Measuring staging for determination of the spectral density of radiated power*

1) The transmitter is connected to the measuring equipment through an attenuator to the spectrum analyzer.

2) In the spectrum of the signal you need to find the frequency of the highest level. The settings of the spectrum analyzer must be as follows:

- *Resolution of 0.3 kHz*
- *Video bandwidth - 0.3 kHz*
- *Span - 1.5 times greater than the the width of the emitted spectrum range.*

3) Records found frequency with the highest level.

4) The center frequency of the spectrum analyzer is set to

the recorded frequency. The span is reduced to 1 MHz and then frequency with the highest level must be located.

5) If the frequency is different from that already written, it must save the new frequency.

6) The center frequency of the spectrum analyzer is set to the found frequency and switches to zero range of span i.e. signals are viewed in their original form. The power indicator of a spectrum analyzer displays the measured power density D.

7) For a TDD equipment an average spectral density PSD of EIRP is calculated from the measured density D and the observed duty cycle **x** on signal:

$$PSD\ [dBm/\ MHz] = D\ [dBm/1\ MHz] + 10lg\ (1/x).$$

When it is necessary to obtain the average spectral density of the EIRP of the output (aperture) of the transmitting antenna gain Gt, working according to the formula:

$$PSD\ [dBm/\ MHz] = D\ [dBm/1\ MHz] - L_a\ [dB] + G_t\ [dBi] + 10lg\ (1/x);$$

With L_a is indicated overall attenuation in attenuator, directional coupler and feeder. It is possible to measure the power spectral density to be done with a device that does not have the option of measuring this parameter - for example, with a simple power meter.

Then the value of the PSD is obtained from the measured power level to the following formula:

$$PSD\ [dBm/MHz] = P_r\ [dBm] - 10lg\ \{BW\ [MHz]\} - L_a\ [dB] + G_t\ [dBi],$$

where P_r is the indication of the unit, *BW* is frequency channel bandwidth and the passing of [dBW] to [dBm] and back, is used dependence:

$$P\ [dBW] = P\ [dBm] - 30.$$

Bandwidth of channel is default and can be one of the following:

- 1.75 MHz;
- 3.5 MHz;
- 7 MHz;
- 14 MHz

(it is selected when the operator planned the network depending on how many subscribers are serviced in that sector and available services).

2. Conclusion

WiMAX broadband data radio systems are an important part of mobile communications, contributing to the development of applications in the sector and increase the opportunities for end users. Gradual, new technologies and standards concerning to improve the quality of services, security and reliability of networks. The report presents an actual problem of possible approaches and mechanisms to measure the output power and power spectral density of radio transceiver of WiMAX broadband data radio network.

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Contacts:

Assoc. professor Rosen Pasarelski,
New Bulgarian University, 21 “Montevideo” str.,
Sofia, Bulgaria;
Phone: +359 2 811 0616;
E-mail: rpasarelski@nbu.bg; rpasarelski@mail.bg