Design of Nano Base Stations for Future Broad Band Applications

K.Murali[1] | P.Aswini Kumar[2]

[1]Assisant Professor, Department of ECE, Vijaya Institute of Technology for Women, Vijayawada.
[2]Assisant Professor, Department of ECE, Eluru College of Engineering , Eluru, India.

ABSTRACT

This paper gives a general overview of the design of base station antennas for mobile communications. It explains underlying theoretical and practical implementation aspects in mobile communication networks of today and the future. In the first part the fundamental parameters of a base station antenna are discussed in the context of radio network design. In particular we discuss parameters such as gain, radiation patterns, frequency bands and power handling and put them in the context of cell planning, propagation and capacity. In the final parts of the paper we give an overview of the Nano base stations for MIMO systems.

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I. Introduction

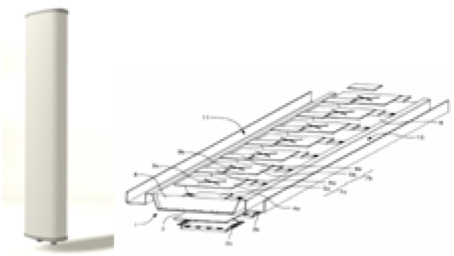

Fig 1:Dual polarized, dual base band antenna from powe wave

Base station antennas for mobile communication systems have during the last two decades exploded in numbers in both our rural areas as well as in our city centers. These antennas (see Figure 1.) are typically 1 to 2 meters long array antennas with gains between 15 and 21 dBi placed in towers between 25 and 75 meters above ground. They have high aperture efficiencies and are able to handle power of up to 500W or more without generating either 2nd or 3rd order passive intermodulation products greater than the system noise floor.

In the mid 90s size reduction was an issue and manufacturers focused on designing flat panel antennas based on e.g. microstrip patches [2]. However, it was soon discovered that it was the number of antennas rather than size that was the main issue for the operators and therefore both dual polarized (for diversity) [3] and multi-band antennas [4] were soon developed.

With the introduction of digital radio systems in mobile telephony in the mid 90ties digital processing of the antenna signals also became an option. Diversity combining at the base station had been implemented already in analog systems but with the digital signal processing one could now also discuss the implementation of digital beamforming and even spatial multiplexing of signals [5].

Today diversity is almost always implemented at the base station. However, recently diversity has also been considered at the mobile terminal. The resulting "Multiple Input Multiple Output", MIMO, system is perceived as a the next important technology step in increasing the data rates that are expected to grow up to and around 100Mbps in e.g. the long term evolution of the 3G systems [6].

II. System Aspects

2.1 Sectorization

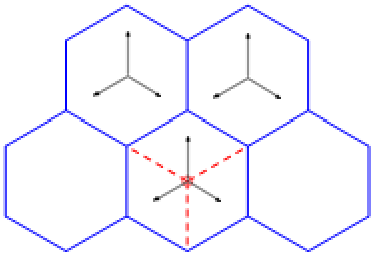

Figure 2: Rhombus cells created by replacing the omni directional antenna at the center of a hexagon by three directional antennas.

Because of the high requirements on capacity, cellular networks are most often sectorized and the use of antennas that are omni-directional in the horizontal plane is very limited today. The most popular choices are base station antennas with horizontal half power beam widths of 65 or 90 degrees. The optimum horizontal and vertical beam width is decided by the network architecture and

III. Technical requirements and overview

The requirements for a base station antenna element operating in the LTE and 3G systems can be seen in Table 1. The limitations for the parameters are set so that the antenna element can operate in an antenna array.

Parameter	Requirement
Impedance	50 Ω
Frequency band	1710 - 2690 MHz
Return loss	>15 dB
Horizontal 3dB beamwidth	60 – 70°
Polarization	+/- 45°
Mechanical dimensions	
– Element separation	<105 mm
– Element height	<50 mm

Table 1: Project requirements.

Impedance

The antenna will be connected to a 50_ coaxial cable. It is therefore important for the antenna element to be matched to an input impedance of 50 ohm

Frequency band

The frequency band 1710 to 2690 MHz includes the current 2G, 3G and the standard for the next generation of wireless mobile system, LTE. In this frequency range, the return loss criterion is 15dB.

Return loss

There is a need for a low return loss to ensure low losses in the antenna system. The return loss coefficient [Eq. 2] is defined as the amount of relative power from the source that is reflected in the system towards the load.

$$RL_{DB} = -10Log_{10}\frac{P_R}{P_T} \qquad (2)$$

Horizontal 3dB beamwidth

The 3dB beamwidth describes the angular separation between two points in the antenna radiation pattern, where the gain is half of its maximum value.

Polarization

The polarization of the antenna describes the direction for the transmitted electrical field, and can be linear, circular or elliptical. Here, a +/- 45 degree linearly polarized antenna is required[3].

Mechanical dimensions

The antenna is supposed to be used in a base station antenna array; see Figure 1 for a typical layout. Hence, there is a limitation in space. The antennas are spaced with 105mm (center to center), the reflector is 137mm in width and the height is limited to 50mm, to fit inside the cover of the base station.

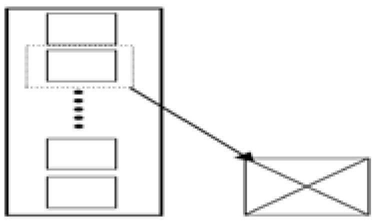

Figure 3: Antenna array in a base station

IV. Proposed Nano Base Station Design

Next-Gen Antenna Design

New antenna array designs featuring 16dBi dual-polarity gain at 5GHz. Optimized cross-polarity isolation and in a compact form-factor.

Integrated AirMax Technology

Unlike standard WiFi protocol, Ubiquiti's Time Division Multiple Access (TDMA) AirMax protocol allows each client to send & receive data using pre-designated time slots scheduled by an intelligent AP controller.[4]

This "time slot" method eliminates hidden node collisions & maximizes air time efficiency. It provides many magnitudes of performance improvements in latency, throughput, & scalability compared to all other outdoor systems in its class.

- **Intelligent QoS** - Priority is given to voice/video for seamless access.
- **Scalability** - High capacity and scalability.
- **Long Distance** - Capable of high speed 15km+ links.
- **Latency** - Multiple features dramatically reduce noise.

Dual Ethernet Connectivity

The New Ubiquiti NanoStation M5 provides a secondary ethernet port with software enabled POE output for seamless IP Video integration.[5]

Intelligent PoE

Remote hardware reset circuitry of Ubiquiti NanoStation M5 allows for device to be reset remotely from power supply location. In addition, any Ubiquiti NanoStation M5 can easily become 802.3af 48V compliant through use of Ubiquiti's Instant 802.3af adapter. Remote reset is an additional option. Ubiquiti NanoStation M5 comes standard as 24V without remote reset.[6]

AirOS V

Version 5 of Ubiquiti's AirOS builds upon the market leading intuitive user-interface loaded with advanced wireless configurations and routing functionality.

Ubiquiti NanoStation M5 Technical Specifications

a) System Information

- Processor Specs: Atheros MIPS 24KC, 400MHz
- Memory Information: 32MB SDRAM, 8MB Flash
- Networking Interface: 2 X 10/100 BASE-TX (Cat. 5, RJ-45) Ethernet

b) RF

- Operating Frequency: 5470 - 5825 MHz
- Tx Output Power 11a:
  - 27 dBm @ 1-24 Mbps
  - 25 dBm @ 36 Mbps
  - 23 dBm @ 48 Mbps
  - 22 dBm @ 54 Mbps

Tx Output Power 11n AirMax:

- 27 dbm @ MCS0
- 27 dbm @ MCS1
- 27 dbm @ MCS2
- 27 dbm @ MCS3
- 26 dbm @ MCS4
- 24 dbm @ MCS5
- 22 dbm @ MCS6
- 21 dbm @ MCS7
- 27 dbm @ MCS8
- 27 dbm @ MCS9
- 27 dbm @ MCS10
- 27 dbm @ MCS11
- 26 dbm @ MCS12
- 24 dbm @ MCS13
- 22 dbm @ MCS14
- 21 dbm @ MCS15

Rx Sensitivity 11a:

- -94 dBm @ 1-24 Mbps
- -80 dBm @ 36 Mbps
- -77 dBm @ 48 Mbps
- -75 dBm @ 54 Mbps

Rx Sensitivity 11n AirMax:

- -96 dbm @ MCS0
- -95 dbm @ MCS1
- -92 dbm @ MCS2

- -90 dbm @ MCS3
- -86 dbm @ MCS4
- -83 dbm @ MCS5
- -77 dbm @ MCS6
- -74 dbm @ MCS7
- -95 dbm @ MCS8
- -93 dbm @ MCS9
- -90 dbm @ MCS10
- -87 dbm @ MCS11
- -84 dbm @ MCS12
- -79 dbm @ MCS13
- -78 dbm @ MCS14
- -75 dbm @ MCS15

c) Antenna

- Antenna Gain: 14.6 - 16.1 dBi
- Cross-pol Isolation: 22 dB minimum
- Polarization: Dual Linear
- Max VSWR: 1.6:1
- Beamwidth: 45 deg. (H-pol) / 41 deg (V-pol) / 15 deg (Elevation)

d) Power

- Power Method: Passive Power over Ethernet (pairs 4, 5+; 7, 8 return)
- Power Supply (included): 24V, 0.5A POE
- Max Power Consumption: 8 Watts

e) Physical

- Enclosure Characteristics: Outdoor UV Stabilized Plastic
- Mounting Kit: Pole straps included
- Operating Temperature: -30C to 75C
- Operating Humidity: 5 to 95% Condensing
- Shock and Vibration: ETSI300-019-1.4
- Dimensions: 294 x 31 x 80 mm

Weight: 0.4 kg[7][8]

V. Conclusions

The expansion of Nano smart-base station antenna technology increases the capacity and coverage of cellular systems. The performance of a narrow-beam base-station (BS) antenna can be enhanced by using space-division multiple access (SDMA), yielding a "smart antenna," as its beam is directed toward the desired user. At the same time, the antenna pattern avoids interference sources by combining direction-of-arrival (DoA) and beam-forming proc- esses. At specific time intervals, a Nano smart antenna produces the desired radiation pattern that changes dynamically, taking into account the position of users and interferers.

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