ISSN No:-2456-2165

Reduction in Transmission Power of Base Transceiver Station

Engr. Aatka Faryal Riaz, Engr. Rafay Azmat Qureshi

Abstract:- Nowadays mobile usage is the essential need of humans. To provide the mobile network services, the Telecommunication companies propose the installation of Base Transceiver Station over large populated and industrial areas. The radiations emit from these BTS may give rise to various electromagnetic and ecological compatibility issues [1]. The radiation power of these BTS is up to 5-10 KiloWatts (up to 320-350 W per channel), which can be detrimental for the human beings, if they are installed in populated areas. The purpose of this paper is to reduce the transmission power of the BTS which is possible through the usage of Self-phased array antenna. Self-phasing array antenna through the use of pilot carrier in Telecommunication systems can degrade the Tx upto10-20dB.

Keywords:- *Transmission Power (Tx), Radiated Power(Rx), Radio Frequency (RF), Effective Power, Telecommunication System, Self phasing antenna, System Design, Base Transceiver Station, Phased Array Antennas.*

I. INTRODUCTION

The issue mentioned in Abstract is resolvable if we lessen the Rx of the BTS but the degradation in the transmission power will also affect the coverage area of the system. There are many other solutions to this.

By dividing the cell into different micro cells can reduce the Tx of BTS but can result in more complicated and cost inefficient system. The most promising way is to use the Self-Phased array antenna for the reduction of Tx. The Self-phased array antenna forms the main beam only in the direction of received signal due to which the power is transferred only in the desired direction and also less power is needed for it but BTS coverage remains unchanged.

The Self-phased array antenna belongs to the Phased array antennas [2].A phased array antenna is group of many antenna elements in which each antenna radiates power individually then the radiation pattern of all antenna combines positively with its adjacent antennas to produce a efficacious pattern which is known as the Main lobe [2]. The direction of the energy of main lobe is targeted to the required area while the antenna is designed in such a way to make interference to the signals in non-targeted directions, to form side and nulls. In phased array the beam is formed by adjusting phase of signals [2].

The beauty of Phased array antennas is that it can receive signal from any direction using its main lobe and re-radiate signal only in the intended direction from where it received [5].

There is another form of phased array antennas, which we proposed as a solution in this paper is “Self-phased array antenna”. This antenna use pilot carrier to perform beam steering. These antennas were developed earlier mainly for Satellite communication which requires the accurate pointing of a high gain antenna. Different types of self-phased array antennas are available but we are considering self-phased array antenna which uses pilot signal for exact positioning and also because of its simplest design. As these antennas are highly directional, they can reduce the Tx of the BTS up to 1 to 2 orders [3] without effecting it’s performance.

II. AIMS AND OBJECTIVE

Our objective is:

- Comparison of Tx of dipole antenna with self-phased array antenna to conclude the most suitable.
- Show the order of reduction in transmission power when using self-phased array antenna.
- Make the transmission more secure.

III. METHODOLOGY

To reduce the transmission power of BTS, the main parameter of antenna is the directivity of antenna. The directivity is inversely related with the radiated power of antenna. The radiation pattern of single antenna is broad that’s why it is less directive. The increased directivity is achievable by using Array of Antennas. The antennas using in the array are usually identical and any type of antenna can be chosen for making array.

There are various other applications where the movement of the beam is required to be changed with time that is usually done by rotating each antenna mechanically in the array with fixed phase. But this method requires a positioning system that is expensive and scans slowly. Here, we are using Phased array antennas because they are fast. Their response is swift because they change the direction of the beam electronically without moving any part [4]. Within Phased Array, we have Self-phasing array which does not need any phase shifter or central control to operate. They are highly directional because they use pilot carrier to generate the beam. They have high gain and narrowing beam width [2] which makes them useful to lessen the Tx of Base station.

Here we are using MATLAB to demonstrate that the Tx can be minimized approximately 10 to 20dB. **MATLAB** (**Matrix Laboratory)**, is one of the leading and best suited software for scientific and engineering numerical computations and data visualization [6]. Nowadays it is widely using in both academies and industries.

IV. SELF –PHASED ARRAY ANTENNA

The self-phased array antenna is the group of different antennas that automatically performs the operation of steering. Each element of the array in self-phasing is independently phased: this phasing is obtained directly from the signal that individual antenna of the array receives. Hence, the antenna array continuously adapts its phase response in order to track an incoming signal.

V. BLOCK DIAGRAM

The figure 1 shows the basic diagram of self-phased array which comprises of same array elements, Self-phasing unit and R.F Splitter/Combiner.

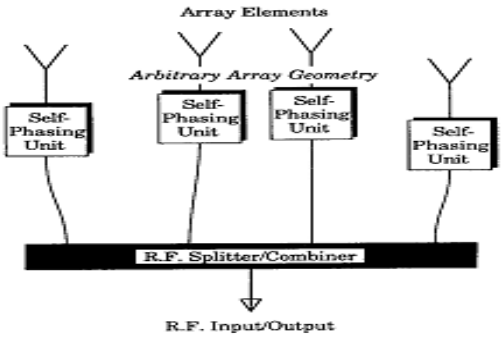


Fig 1: Self phased array antenna

A. ARRAY ELEMENTS

The term Array Elements means the antenna's types used to construct the array.

Fig: Antenna Array

B. SELF-PHASING UNIT

This Unit performs operations on received signal and re-transmit it. It receives arriving signal from antenna, implements the operation of phasing on it and then retransmit it back only in the direction of receiving signal.

C. COMBINER / SPLITTER

It works on RF. At the Transmission side it splits RF into components in order to send them through antenna and at the receiving side it combines all the radio frequencies taking from the antennas.

VI. WORKING PRINCIPLE

The self-phased array performs phase compensation to achieve beam steering. In these antennas, the phase compensation is obtained by mixing pilot carrier present in the broadcast signal as a reference and primary signal. The figure 2 shows the receiving and transmitting array elements

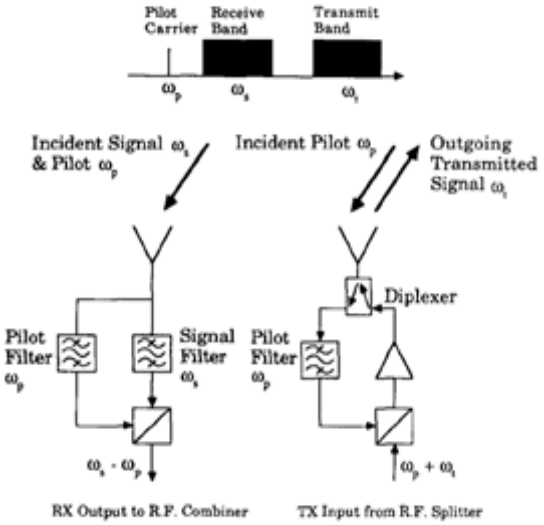


Fig.2. Receiving & Transmitting Array

At Reception Side:

In the receive configuration, the pilot carrier (transmitted by the source along with a band containing information signal) is received at each antenna of the array and is separated by using filter. This pilot carrier is then used as a local oscillator to down-convert the signal band. The phase compensation is done in the Mixer during the multiplication of pilot and primary signals. For the array to work effectively the pilot tone must be closed to the signal frequency, so the array output is at a very much lower frequency than incoming RF signals. Considering the operation of an array with extreme elements spaced apart by a distance L, the output signal phases at each end of the array are [2]:

(ws-wp)t and (ws-wp)t + ψp-ψs,

where,

Ψp – ψs : represents the shift in phase of the pilot and signal wave fronts due to the difference in path length between elements. But as pilot and the signal frequency are same, their phases closely match with each other through space. Thus, providing the array is not very big, the phase error term, (ψp–ψs) is negligible Consequently, each antenna's outputs in the array are very similar in phase and can be summed up positively for maximum response.[2]

ISSN No:-2456-2165

At Transmission Side:

The phase information of the recovered pilot signal is utilized in the same way as it was used at the time of reception for the re-transmission of the signal. The mixing process is now set out to produce the phase conjugation which is needed for retro transmitting array. The phase obtained from the pilot signal is mixed with the transmitting signal, so that the signal can be send only on the desired path.[2]

VII. WHY SELF-PHASED ARRAY ANTENNA

A. NO CENTRAL CONTROL HARDWARE

In these antennas, there is no any need of central control hardware because every antenna of the array performs self-phasing individually.

B. RAPID SIGNAL TRACKING CAPABILITY

This antenna can track the signal very fast. It is inherently capable of high agility due to the fact that array phasing in this antennas is achieved automatically at each element.[2]

C. POTENTIAL FOR COST SAVING

The self-phasing array antenna also has some other benefits except adaptively steered phased arrays. It is comparatively cheaper than others because of the elimination of any central control system.

D. More Secure

The self-phased array antennas are more secure. They use pilot carrier as a reference which makes the transmission more secure.

VIII. SYSTEM DESIGN

In this system design Dipole antennas are used to make the array.

A. Dipole Antenna

It is one of the simplest and mostly used antennas. The commonly used dipole antenna is made up of two identical conductive straight rods/wires (which are usually bilaterally symmetrical [7]) connected on the same axis, and the feeder cable is connected at the adjacent edge, but the feed line can be connected anywhere depending on the length of dipole. Dipoles antennas are the resonant antennas. The wavelength of radio waves determines the dipole elements' length. The commonly used dipole antenna is the half-wave dipole, which is made up of two rod elements and the length of each element is nearly $1/4^{th}$ of wavelength which combines to make ½ wavelength long antenna [7]. The vertical dipole antenna radiates Omni directionally i.e. the power spread equally in all directions normal to the antenna's axis.

Fig1: Dipole Antenna

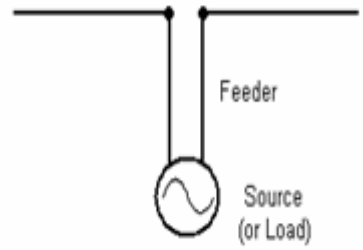


Fig 2. Antenna (Dipole with feeder cable)

We are using dipole antenna for making self-phased array system. The mentioned below equation is used for the calculation of the transmission power generated by single dipole antenna[3]:

$$P_{t,d} = \frac{P_e}{G_d}$$

(1)

$P_{t,d}$:Tx of single dipole antenna

G_d: Gain of dipole antenna

By substituting $G_d = 1.64$ the equation 1 becomes[3]:

$$P_{t,d} = \frac{P_e}{1.64}$$

(2)

P_t(Transmission Power of self-phased array antenna) can be calculated as [3]:

$$P_t = \frac{1.64 * P_{t,d}}{G}$$

(3)

Where;

G represents the gain of Array, if "N" dipole antennas are used to make the array then this "G" will become N*1.64.

IX. SIMULATION OUTPUTS

A. Single Dipole Antenna

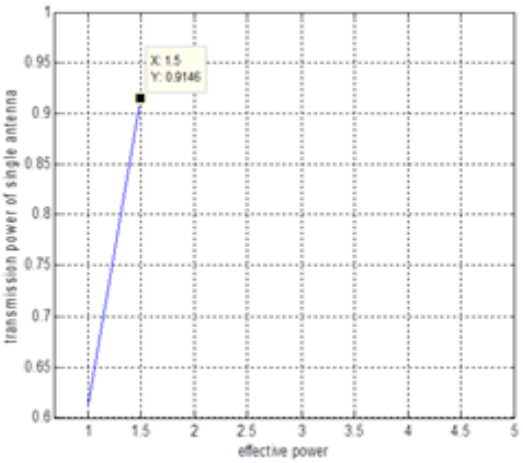
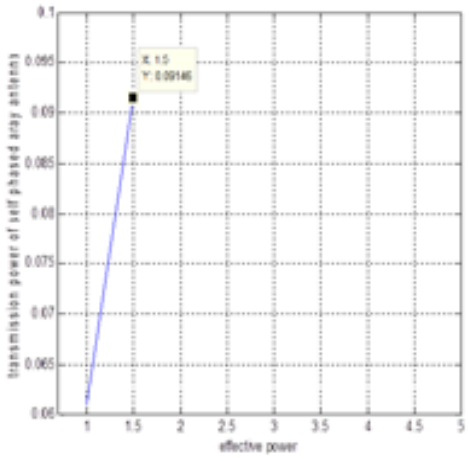


Fig.3. Transmission power of dipole antenna

Graph.1. Transmission power of dipole antenna

The $P_{t,d}$ at different values of effective power P_e is shown in graph 1. We can see that the Transmitted Power $P_{t,d}$ is 0.91, when the P_e is 1.5.

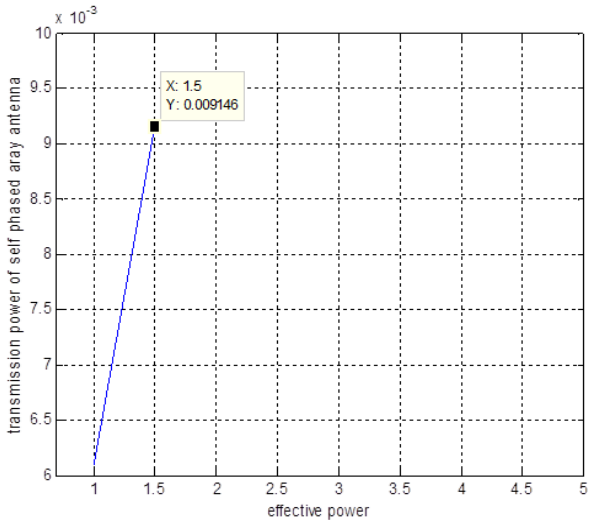
B. Self-phased Array Antenna with 10 Dipole Antennas



Graph.2. Transmission power of self-phased array antenna with 10 Dipoles.

The Graph 2 presents the values of Tx and the Effective Power when using self-phased array antennas. This self-phased array system consist of ten antennas and it is also showing that the value of P_t is 0.09 when P_e is 1.5.

C. Self-phased Array Antenna with 100 Dipole Antennas



Graph.3.Transmission power of self-phased array antenna with 100 Dipole.

Graph 3 is showing the values of P_t and the Effective Power P_e, when using self-phased array antennas. This time the system consist of 100 dipole antennas and we can see that when Effective Power is equal to 1.5, the value of P_t is equal to 0.009.

D. Comparison Of Transmission Power

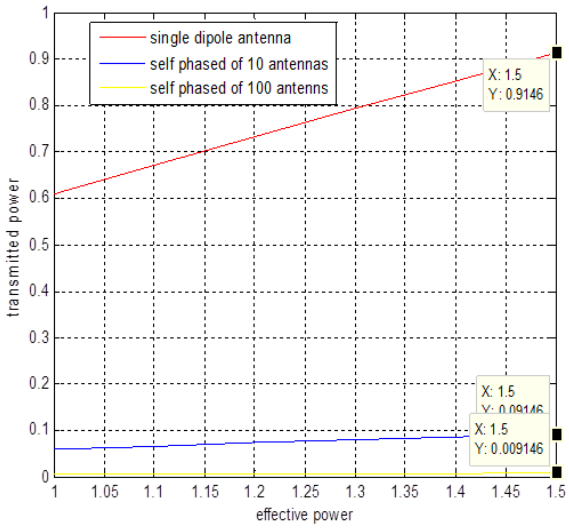


Fig.4 Comparison of transmission power

In Figure 4 we can see the comparison between the transmission power of single dipole antenna and the Self-phased array antenna. It can be seen that the transmission power is reduced when we used the self-phased array antenna instead of single dipole antenna without any effect on the effective Power.

ISSN No:-2456-2165

At P_e= 1.5 the transmitted power of a dipole antenna is 0.9, the value of transmitted power generated by self-phased array system made by using 10 dipole is 0.09 and when using self-phased array system comprising of 100 dipoles is 0.009.

IX. POWER REDUCTION FACTOR

We can use the following equation to calculate the power reduction:

$$R = \frac{P_{t,d}}{P_t} \qquad (4)$$

The Power reduction value is 10dB when using array consisting of 10 dipole antenna is:

$$R = \frac{0.9}{0.09}$$

R= 10 dB

When we use 100 dipole antennas the Power reduction factor becomes 20dB as shown below:

$$R = \frac{0.9}{0.009}$$

R = 20 dB

Therefore the usage of self-phasing array on the BTS can reduce the power by 10 to 20 dB (for N=10-100).

X. LITERATURE REVIEW

Widespread use of mobile phone leads to the installation of BTS in populated areas. The emission of electromagnetic radiations from these base stations can be inimical for humans. But presently as the mobile usage is considered as the essential needs of life we cannot remove it rather we can minimize its generated power. Many other researchers suggest that if we use self-phased array antennas instead of ordinary antennas, this power can be reduced upto 10 to 20dB [3]. In this research paper we showed this graphically through coding in MATLAB.

XI. CONCLUSION

The Self-phased array antenna is the uncomplicated and cost effective solution for the reduction of transmission power. Because of its highly directive property not only it produces the narrow beam width but also provide more secure environment.

REFERENCES

[1]. S L Loyka "Directivity of Self-phased Arrays in Conditions of Multipath Propagation'HF Radio Systems and Techniques', 7-10 July 1997, Conference Publication No. 41 1, *0* IEE, 1997
[2]. Paul V. Brennan "An Experimental and Theoretical Study of Self-phased Arrays in Mobile Satellite Communications" IEEE Transactions on Antennas and Propagation, VOL. 31, NO. 11, NOVEMBER 1989.
[3]. Sergey L. Loyka and Vladimir I. Mordachev "On Applications of Self-Phased Array Antennas to Mobile Communications" Belorussian State University of Informatics & Radioelectronics.
[4]. Microwave Encyclopedia
[5]. Phased Array Beamforming ICs Simplify Antenna Design by Keith Benson
[6]. www.mathworks.com
[7]. Design of Dipole Antenna and various radiation patterns for various lengths
[8]. S.L. Loyka, Influence of Pilot Signal on Directivity of Self-Phased Arrays Under Conditions ofMultipath Propagation, IEEE Trans. on EMC, vol.40, No.1, pp.12-18, 1998.
[9]. Phased Array Beamforming ICs Simplify Antenna Design
[10]. S.L. Loyka, On Operation of Self-Phased Arrays Under Conditions of Multipath Propagation, Int. Conf. on Microwave & Radar (MIKON-98), Poland, Krakow, 1998, pp.535-539.