Analysis of Cell Tower Radiations & Practical Realization of Compliance Distance

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Abstract- The effect of electromagnetic radiation on human health is the subject of recent interest and study. ICNIRP (International Commission on Non-Ionizing Radiation Protection) study has concluded that the exposure levels due to cell phone base stations are generally around one-ten-thousandth of the guideline levels. Moreover, the WHO has classified mobile phone radiation on the IARC (International Agency for Research on Cancer) scale into Group 2B – possibly carcinogenic to humans. That means that there could be some risk. On the other hand, telecom service providers are worried about QoS (quality of service) of mobile services after implementation of stricter norms regarding cell tower radiations. Therefore an exercise was done to measure cell tower radiations at various places of dense urban regions, in the context of QoS measurement at these places. Exercise was also done to understand near field behavior of mobile towers and practically realization of compliance distance. This paper deals with practically observed radiation level (power density) and QoS benchmarks at various sample points along with practically realization of safer zone from cell tower radiation point for various sets of EIRP/ERP, antenna gain, bands etc. Comparison among theoretical and practically observed values of signal strength/power density/EIRP is also done with MATLAB program**.**

Index Terms- Cell tower radiation, Compliance Distance , ICNIRP, QoS.

I. INTRODUCTION

Cell phone technology has grown exponentially in the last decade. Large number of BTSs/towers is to be deployed to meet the communication demand. Presence of large number of cell phone towers in populated area starts the debate on biological impact of cell tower radiation. Most of the countries has adopted the radiation norms as suggested by the ICNIRP.As per the ICNIRP, the value of power density at general public exposure zone should be less then f/200 watt/m^2 for 400-2000 MHz band. Here f is the frequency used by the mobile operator in Mhz. Still some researchers are demanding to strengthen the radiation norms i.e. recommended value of power density at safer distance(that is expose to general public) should be as low as possible. At the same time telecom service providers are opposing such demands and arguing that reduction in transmitted power/EIRP (effective isotropic radiated power) for reducing the risk of radiation may hamper the QoS of mobile operation.

Some researches theoretically proves that presence of large number of antennas on single tower with multiple carriers from each antenna may cause sifting of compliance zone very much away from the tower and general public exposure area comes in accidence zone where power density is very much high then the recommended value.

Hence a research was done to measure cumulative cell tower radiation values at various dense populated urban areas and QoS parameters were also measured to analyze both power density (radiation level) and QoS in collective manner.

A research was also done to measure radiation level at various distances for various sets of BTS /mobile towers to understand near field behavior of mobile antennas and to find out the compliance distance and its dependency on various factors like antenna gain, transmitted power, bands etc.

II. EMF EXPOSURE ZONE

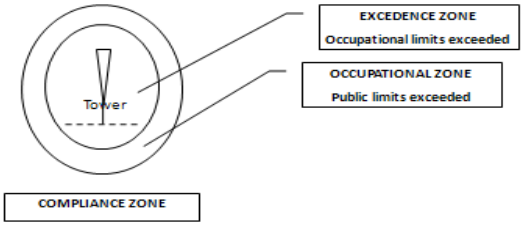


Figure 1- EMF exposure zone

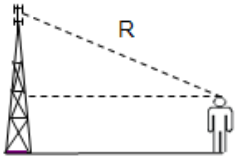
A. Excedence zone – This zone has restricted access to workers and the general public.

B. Occupational zone- This zone is restricted access to general public. Physical barriers lock out procedures or adequate signs can accomplish the access restriction. Workers may be permitted to enter the occupational zone.

C. Compliance zone- This has EMF value below the applicable limits and it is treated as safer zone for general public.

III. POWER DENSITY AND RADIATION LEVEL

The power density at any distance from an isotropic antenna is simply the transmitter power divided by the surface area of a sphere at that distance. The surface area of the sphere increases by the square of the radius, therefore the power density, PD, (watts/square meter) decreases by the square of the radius.



$$S = \frac{PG}{4\pi R^2}$$

Where: S = Power density (W/m^2),
P = Power input to the antenna (W)
G = Power gain of the antenna
R = Distance to the center of radiation of the antenna (m)

Table1-Compliance distance recommended by ICNIRP (based on ITU K.70 fact sheet formula)

Radio Frequency Range	General Public Exposure	General Public Exposure
1 to 10 MHz	r = 0.10 $\sqrt{eirp \times f}$	r = 0.129√erp×f
10 to 400 MHz	r = 0.319 $\sqrt{eirp}$	r = 0.409 $\sqrt{erp}$
400 to 2000MHz	r = 6.38 $\sqrt{eirp}/f$	r = 8.16 $\sqrt{erp}/f$
2000 to 300000MHz	r = 0.143 $\sqrt{eirp}/f$	r = 0.184 $\sqrt{erp}$

Where r is compliance distance in meters, f is the frequency in MHz and EIRP is equivalent isotropically radiated power in the direction of maximum antenna gain in watts while ERP is effective power in the direction of maximum antenna gain in watts.

IV. ANALYSIS OF CELL TOWER RADIATIONS

Cell tower radiation measurement methods can be classified in three categories:-

1. Calculation method
   a. Prediction of RF fields
   b. Calculation to determine $EIRP_{th}$
2. Software simulation
3. Field measurement

Field measurement approach was chosen to analyze cell tower radiations in various regions.

Approach:-

Ten test points were chosen. Following were considered in area selection

1. Area should be such that it should be covered by all major GSM operators radiating with GSM 900 & 1800 MHz bands. It should also serve by major CDMA operators.
2. Large number of closely situated shared towers with many antennas should be present in that dense urban area.
3. Preferably it should be border area of two or more PLMNs, so that interference/ radiations from nearby PLMNs can also be taken in to account.
4. Site data & other technical data regarding that area should be available.

Following points were chosen in Ghaziabad (India) as per the availability of maximum number of towers/ antennas in that area.

Table. 2- Area chosen for measurement.

Point 1	Raj Nagar, Sector 10 Ghaziabad, Latitude 77.23263 Longitude 28.60146
Point 2	New Railway Station, Latitude 77.44944, Longitude 28.682192
Point 3	Meerut Road, Latitude 77.44812, Longitude 28.702333
Point 4	Kavi Nagar Ramleela Ground, Latitude 77.449869 , Longitude 28.66651
Point 5	Shastri Nagar Water Tank, Latitude 77.464519 , Longitude 28.672718
Point 6	Govind Puram, Latitude 77.564163 , Longitude 28.683962
Point7	Nand Gram Ghaziabad, Latitude 77.427692, Longitude 28.689759
Point 8	Bamheta, Latitude 77.506142 , Longitude 28.646155
Point 9	Bamheta, Latitude 77.506142 , Longitude 28.646155
Point 10	Vijay nagar, Latitude 77.431169 , Longitude 28.647775

Network quality reports related to that area were studied to see the QoS of mobile services. TEAMS drive testing handset was also used to observe the network performance. Also, personal interview was conducted to find out the QoS in term of customer satisfaction. this formula is explained as under:-

Maximum value of QoS=1

Sr.No.	Parameter	Weightage in QoS formula
1	SDCCH BLOCK	1/20 if SDCCH block is < 1%, otherwise zero.
2	SDCCH DROP	1/10 if SDCCH drop is < 1%, otherwise zero.
3	TCH BLOCK	1/20 if TCH block is < 2%, otherwise zero.
4	TCH DROP	1/5 if TCH drop is < 2%, otherwise zero.
5	Call completion success ratio	1/5 if CCSR > 95%, otherwise zero
6	Rx signal Strength	1/5 If Rx signal > -95 dBm , 1/10 >-103dBm otherwise zero.
7	Rx quality.	1/5 for Rx Quality 0 to 3 ,1/10 for Rx Quality 4 to 5 , otherwise zero

Graph regarding observed power density at various places at compliance distance is shown below.

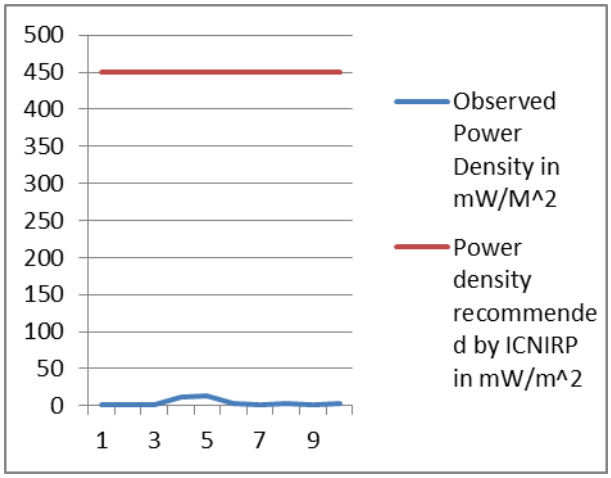


Figure 2- observed power density at various places at compliance distance

Graph among ratio of measured and recommended power density and QoS is shown below.

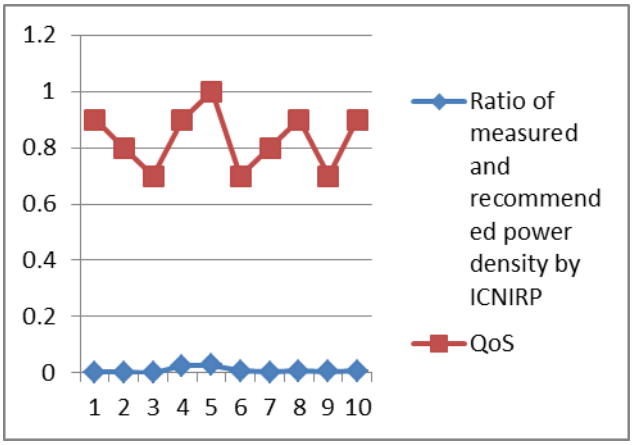


Figure 3- Ratio of measured and recommended power density and QoS

It can be realized that power density measured varies from 0.66 to 11.2 mW/m^2 and the QoS is also between 0.7 to 1. Ratio of practically observed and recommended power density varies from 0.028 to 0.0013 at compliance distances at these critical sites.

Hence it can be stated that telecom operators are radiating below the 1/100 to 1/1000 value of maximum allowable power density and even they were able to manage good QoS, so radiation norms can be further strengthen i.e. recommended power density at compliance distance may be f/2000 or less then it.

V. Realization of Compliance Distance

This exercise was done to realize compliance zone for a particular BTS/ antenna. Then various parameters like transmitted power, antenna gain, frequency, antenna height, tilt etc were vary to observe dependency of these factors on compliance distance.

Approach

A BTS site was chosen (test bed of GSM). It was not utilize by the general public so various parameters like frequency, transmitted power , hopping etc were changed & with the help of ANRITSU_MS2661A-11 spectrum analyzer and Narda SRM 3006 Frequency-selective meter power density/ electric field strength were measured at various points to find out the point where power density would be less then f/2000 watt/m^2 & f/400(Watt/m^2) to find out compliance & occupational zone. Then graphs between observed power density/ electric field strength & distance was drawn for various sets of configuration(like transmitted power, antenna gain, antenna height, frequency etc) to observe the dependency of various factors on compliance distance.

Near field behavior was observed for the following specifications:-

Transmitting power:- 43dBm Antenna Gain= 17 dBi
3dB beam width vertical θbw(deg)= 7.5
BCCH frequency= 949.2 Mhz Antenna height= 4m
Antenna Tilt(Electrical + Mechanical)=4 degree
RX cable length=32m Side lobe attenuation=15 Db
Cable unit loss (dB/100m)= 3

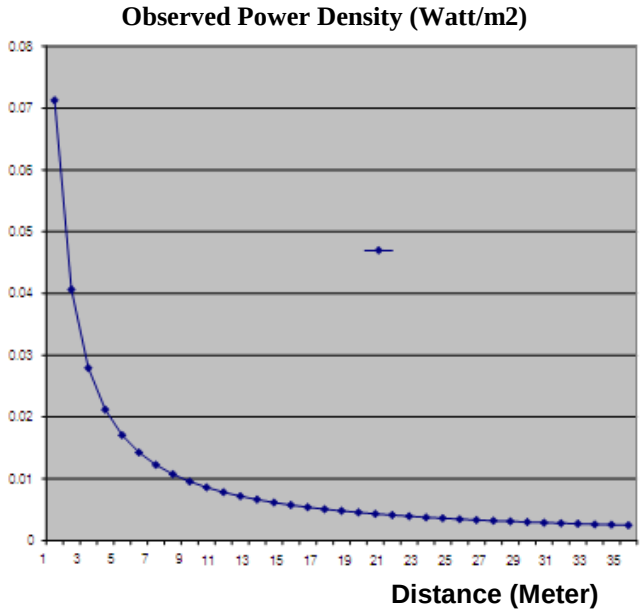


Figure 4 -Observed Power Density (Watt/m2

Graph shown above represent near field behavior of directional antenna. It is almost similar to exponential decay .

Here if power density f/20000 will be considered for the compliance distance then it can be seen that observed compliance distance is between 3 to4 m(for one carrier per sector).

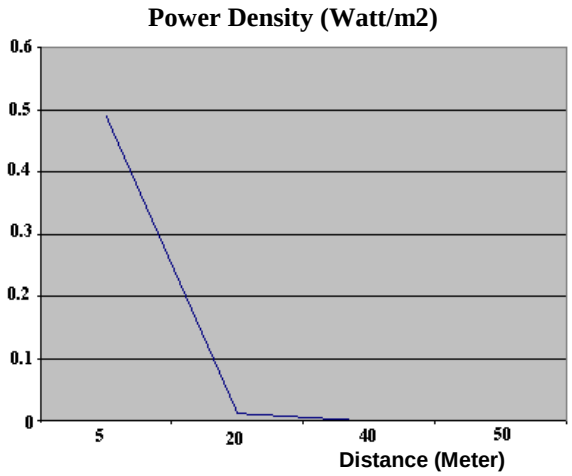


Figure 5- Near field behavior of GSM antenna with 4 carriers in one sector

Graph shown above show the near field behavior of GSM antenna with 4 carriers in one sector. It can be observed that if power density f/20000 will be considered for the compliance distance then it can be seen that observed compliance distance is between 14 to 18 m. For 36 carriers the 57.5m was observed as compliance distance.

Graph shown below represent electric field strength at various distance for various antenna gain. It can be observed that antenna with high gain offer higher value of power density/ electric field strength in near field region as compare to low gain antenna.

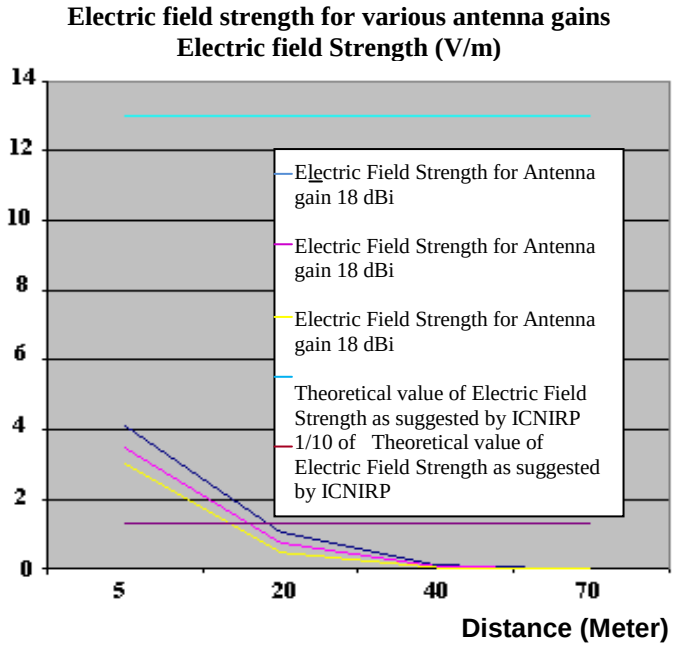


Figure 6- electric field strength at various distances for GSM 900 & 1800

Graph shown below represent electric field strength at various distance for GSM 900 & 1800 for the same transmitting power. It can be observed GSM 900 offers antenna with higher value of power density/ electric field strength in near field region as compare to GSM 1800.

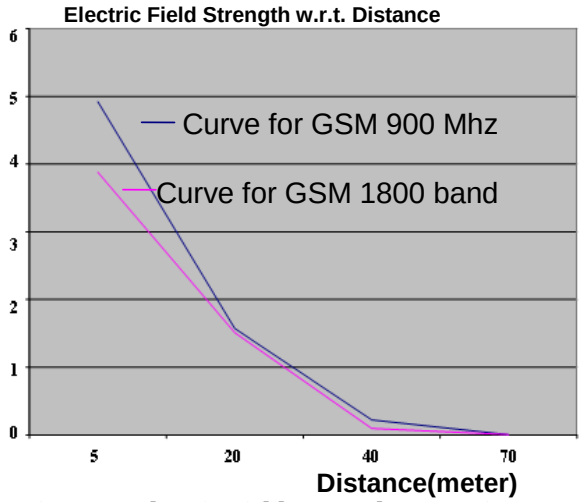


Figure 7- Electric Field Strength w.r.t. Distance

then observed compliance distance was between 2 to 3 m.(for maximum power transmitted i.e. 43 dBm & antenna gain 18 dBi) But this was the case of 1 carrier per sector.

When 6 carriers were used per sector, then compliance distance increases by 4 times.for 36 carriers the observed compliance distance was 57.5m.

As shown in graphs, compliance distance varies with antenna gain, transmitting power, frequency etc. It was also observed that frequency hopping did not put any influence on compliance distance.

VI. CONCLUSION

This paper was concern with practical measurement of cell tower radiation and QoS along with realization of compliance distance for various antenna gain and bands. It was observed that operators were able to manage radiation level 1/100 to 1/1000 below the recommended value while maintaining QoS. So, so radiation norms can be further strengthened i.e. recommended power density at compliance distance may be f/20000 or less then it. It was observed that compliance distance for 6 carriers with 18dBi antenna gain and 43dBm EIRP was near about 12 meters from the tower and for 36 carriers this value reaches to 57.5 meter. It was also observed that compliance distance varies with antenna gain, transmitting power, frequency etc. Frequency hopping did not put any influence on compliance distance.

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AUTHORS

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