IJISET - International Journal of Innovative Science, Engineering & Technology, Vol. 6 Issue 4, April 2019
ISSN (Online) 2348 – 7968
www.ijiset.com

Assessment of Mobile Network Signal Strength For Gsm Networks In Gusau, Zamfara State

Sa'adu L.[1], Maduka N. C.[2], Kado A.[3], Abdulmuminu I.[4] and Bello M.[5]

[1,2,3,4,5]Department of Physics, Federal University Gusau, P.M.B 1001, Zamfara State, Nigeria.

Corresponding Authors' Email & Phone no.: nosytron@yahoo.co.uk, Tel.: +2348037434986

Abstract

Despite the availability of different GSM network service providers in Nigeria, many parts of the country still experience huge poor network service. This paper presents an assessment of the signal strength in Decibel (*dBm*) of GSM network service providers in Federal University, Gusau - the central part of Zamfara State. The investigated three GSM operators *Airtel, GLO* and *Etisalat* are designated as operator X, Y and Z. Data on the signal strength of these network operators are collected at the office of the National Space Research and Development Agency (NASRDA) in the University. This Research Institute uses a Field Strength Meter, precisely ***Ku band*** which is a kind of Receiver to generate these data at every five minutes daily in the Institution. The collected data were averaged, analysed graphically and compared with each other to see the performance of each of the GSM network operators in the study area. The results revealed that the performances of these network providers are yet to be adjudged satisfactory. This study would help Network operators to improve quality, ensure improved network coverage and increase capacity in future.

Keywords: GSM Network, Signal Strength, Receiver, Decibel, Field Strength Meter, Ku band.

1. INTRODUCTION

From time immemorial, information and communication have fashioned the basis of human existence. People want to communicate their family and friends and to be communicated. This desire has been a driving force, inspiring people to continuously seek for a new and effective means of dissemination of information to one another on real time basis irrespective of distance. The development in technology ushered in this desire with advent of the first generation cellular telephone systems that enable people to communicate with one another irrespective of time and place. This first generation cellular telephone system, which was analog system, was launched in 1960s before digital communication became prevalent [1-5]. People want to get in touch with their family and friends. This desire makes it all the more frustrating when the network is poor or doesn't go through at all. There have been serious complains raised by GSM subscribers regarding poor quality of services (QoS) rendered by the GSM operators in this study area. The most annoying aspect of this is the fact that all the GSM subscribers irrespective of the operator are being affected [6].

Many mobile phone users rely on signal bars as the measure of coverage. If a call is dropped or a web page begins to buffer, bars are typically the first thing one always look at. In reality, however those bars have little to do with the actual strength of the cell signal one is getting. The number of bars can vary based on cell carrier, phone manufacturer, or even the way one holds the phone. The bottom line is that there is no standard for what these bars means or what they actually measure be it data or voice performance across 3G, 4G, or 5G networks. It may sound simple, but the only real evidence of signal strength that matters is call clarity and the number of dropped calls.

A mobile phone signal (also known as reception and service) is the signal strength (measured in *dBm*) received by a mobile phone from a cellular network (on the downlink). Depending on various factors, such as proximity to a tower, any obstructions such as buildings, trees, rocks, etc, this signal strength will vary [6].

In telecommunication, particularly in radio frequency, signal strength (also referred to as field strength) refers to the transmitter power output as received by a reference antenna at a distance from the transmitting antenna. For very low-power systems, such as mobile phones – signal strength is usually expressed in dB-microvolts per metre (*dBμV/m*) or in decibels above a reference level of one milliwatt (*dBm*) [7].

The estimated received signal strength in a mobile device can be estimated as follows:

$$dBm_e = -113.0 - 40.0\, log_{10}\frac{r}{R} \quad (1)$$

More general one can take the path loss exponent into account:

$$dBm_e = -113.0 - 10.0\, \gamma\, log_{10}\frac{r}{R} \quad (2)$$

Where

dBm_e	is the estimated received power in mobile device
-113.0	the minimum received power
40	is the average path loss per decade for mobile networks
r	is the distance mobile device-cell tower
R	the mean radius of the cell tower
γ	is the path loss exponent (average value of 4 for mobile networks) [8].

If the mobile device is at cell radius distance from the cell tower the received power is estimated as -113*dBm*. The effective path loss is depending on the frequency, the topography, and the environmental conditions [8].

There has been complains by network subscribers due to the poor quality of services (QoS) rendered by the GSM operators in the study area. The most annoying aspect of it is the fact that all the GSM subscribers irrespective of the operator are being affected as well. Based on this ugly experience, this study was embarked upon to examine the causes of these problems and find ways to proffer solutions to them. This paper therefore measures signal strength of GSM networks (X, Y and Z) in Federal University, Gusau- the central part of Zamfara State with the view to addressing the complaint of the users.

2. LITERATURE REVIEW

The use of cell phones has increased so rapidly that wireless networks are becoming overloaded, resulting in a growing number of customer complaints about the quality of the service provided. The problems in cell phone service are compounded by economics as more customers have been attracted by the decline in cost of service. The percentage of all wireless subscribers who have called customer-service centres at least once in the past year to complain about service or because they had other problems has climbed to 61%, from 53% (15% rate increase) in 2000, according to J.D. Power and Associates (2003), a firm that measures customer satisfaction in many industries and sells the information to the companies being scrutinized. Experts expect complaints to grow as companies add services, contributing to stress on the networks and subscribers' confusion. Thus, wireless companies need to invest more money to accommodate all the new users. The number of satisfaction studies reviewed indicates that carriers are focused on satisfaction in this highly competitive market and have realized that customer satisfaction is a key to survival and that investing strategically is the primary way to gain advantage over the competition [9-12].

Many researchers hitherto have worked on several aspects of the mobile networks especially the quality of service and received signal strength. Some of such works are here reviewed. The authors in [13], carried out a comparative study of the network performance of GLO and MTN. The researchers adopted an interview method to embark on the study thus interviewing mostly professionals and the public. Questionnaires were also deployed and visual observations made.

In [14], An Evaluation of Outgoing Calls using a net monitor software installed on a Nokia 3310 mobile was carried out. The software consists of a scale which represents the percentage power for inter and intra network outgoing call level. Similarly, the authors in [14] using the GLO network and the net monitor software installed on a Nokia 3310 mobile carried out an investigation and modelling of power received at 1800MHZ in mountainous Terrain. The authors in [15] carried out their evaluation of the GSM signal strength in terms of the network service bars. They employed the use of Nokia L600 GSM dual band (signal strength detector) supported by General Packet Radio Service (GPRS). In [15], the authors used an analysis of Received Signal Strength in predicting the models for Radio network planning of GSM 900Hz.

The authors in [16] worked on the analysis of mobile networks signal strength for GSM networks. In their work, drive tests were used to measure the signal strength for GSM networks during Shiloh, an annual program in Canaan land, Ogun State, where about 250000 people converged. The drive is taken immediately after the end of each meeting session when people tend to reach out to families and friends at different places. Networks that are well designed and those that need optimization were identified.

3. METHODOLOGY

As earlier stated, data on mobile network signal strength of service providers X, Y and Z used for this assessment was collected from the office of the National Space Research and Development Agency (NASRDA) in the University. The data collected is for the period of thirty (30) days. The signal strength of these network providers are generated at every five (5) minutes of each day, making a total of 288 data per day and a total of 8640 data for the thirty days. These data are analysed using pie charts and a graph.

This Institute makes use of Field Strength meter (FS) to generate these data along with data on other physical conditions. The key electronic gadgets used by NASRDA to generate these data are briefly described as follows:

3.1 Field Strength Meter (FS)

FS is actually a simple receiver. After a tuner circuit, the signal is detected and feed to a micro ammeter, which is sealed in *dBm*. The frequency range of the tuner is usually within the terrestrial broadcasting bands. Some FS meters cans also receive Television Receive – Only (TVRO) and Radio Receive – Only (RRO) satellite frequencies. Most modern FS meters have Audio frequency (AF) and Video frequency (VF) circuits and can be used as standard receivers. Some FS meters are also equipped with printers to record received field strength [17]. Figure 1.3 shows the FS meter, AF and VF gadgets and display unit used by NASRDA to generate network signal strength data.

3.2 Ku Band

Ku band is primarily used for satellite communications, most notably for fixed and broadcast such as National Aeronautics and Space Administration's (NASA) Tracking Data Relay Satellite used for both space shuttle and International Space Station (ISS) communications. The band is split by the International Telecommunication Union (ITU) into multiple segments that vary by geographical region. Europe and Africa are represented by ITU Region 1 and they are, the 11.45 to 11.7 and 12.5 to 12.75GHz bands are allocated to the FSS (FIXED SATELLITE SERVICE, uplink 14.0 to 14.5GHz) [18].

3.3 Antenna

When measuring with a field strength meter it is important to use a calibrated antenna such as the standard antenna supplied with the meter. For precision measurements the antenna must be at a standard height. A value of standard height frequency employed for Very High Frequency (VHF) and Ultra High Frequency (UHF) measurement is 10 metres (33ft). Gain correction tables may be provided with the metre that takes into account the change of antenna gains with frequency [19].

4. RESULT AND DISCUSSION

Part of the data collected from NASRDA is shown in Table 4.1. The table shows a comparison of the various Received Signal Strength (RSS) for the three networks under study. It also gives an insight into the performance of these networks, how efficient the RF planning by the companies was done. It consists of the date, time, RSS in *dBm* and KU-Band signals in *Ghz*.

Table 4.1: Shows RSS Signals and KU Band Signals of the investigated Network Providers as generated by NASRDA

DATE	TIME	-----	RSS SIGNALS	-----	KU BAND SIGNAL	
	-----	X	Y	Z	11.7-12.7*Ghz*, V	
	HH:MM	*dBm*	*dBm*	*dBm*	*dBm*	
01/06/2017	#0:05	-78	-78	-72	-36.9176	
01/06/2017	#0:10	-78	-78	-72	-36.9176	
01/06/2017	#0:15	-78	-78	-72	-36.7236	
01/06/2017	#0:20	-78	-78	-72	-36.1416	
01/06/2017	#0:25	-78	-78	-72	-35.9476	
01/06/2017	#0:30	-78	-78	-72	-36.9176	
01/06/2017	#0:35	-78	-78	-72	-36.1416	
01/06/2017	#0:40	-78	-78	-72	-36.5296	
01/06/2017	#0:45	-79	-78	-72	-36.7236	
01/06/2017	#0:50	-79	-78	-72	-36.7236	
01/06/2017	#0:55	-79	-78	-72	-36.1416	
01/06/2017	#1:00	-79	-78	-72	-36.9176	
01/06/2017	#1:05	-79	-78	-72	-36.7236	
01/06/2017	#1:10	-79	-78	-72	-35.7536	
01/06/2017	#1:15	-79	-78	-72	-34.0076	
01/06/2017	#1:20	-79	-78	-72	-36.9176	
01/06/2017	#1:25	-79	-78	-72	-37.1116	
01/06/2017	#1:30	-79	-78	-72	-37.1116	
01/06/2017	#1:35	-79	-78	-72	-36.9176	
01/06/2017	#1:40	-79	-78	-72	-37.1116	
01/06/2017	#1:45	-79	-78	-72	-37.1116	
01/06/2017	#1:50	-79	-78	-72	-37.1116	
01/06/2017	#1:55	-79	-78	-72	-36.9176	
01/06/2017	#2:00	-79	-78	-72	-37.1116	
01/06/2017	#2:05	-79	-78	-72	-37.1116	
01/06/2017	#2:10	-79	-78	-72	-37.1116	
01/06/2017	#2:15	-79	-78	-72	-37.1116	
01/06/2017	#2:20	-79	-78	-72	-36.9176	
01/06/2017	#2:25	-79	-78	-72	-36.3356	
01/06/2017	#2:30	-79	-78	-72	-37.1116	

As one can see, these signals are collected every five (5) minutes of the day generating huge number of data. Because of this, the signals are averaged per day, reducing it to a single data per day for each Network provider as shown in Table 4.2.

Table 4.2: Shows the Averaged RSS Signals per day of the investigated Network Providers.

	X *dBm*	Y *dBm*	Z *dBm*
Day1	-79.2222	-78	-72
Day2	-82.1522	-80.2935	-74.0924
Day3	-80.7448	-76.5724	-70.4414
Day4	-79.3958	-78.7188	-71.9931
Day5	-79.0798	-78.8063	-72.0342
Day6	-78.7523	-78.2131	-71.3078
Day7	-80.2713	-77.5635	-78.6
Day8	-83.9618	-77.125	-79.066
Day9	-82.0852	-76.8974	-69.9722
Day10	-81.4021	-77.7675	-70.028
Day11	-79.9583	-77.9861	-70.7083
Day12	-80.8438	-78	-70.7222
Day13	-79.5817	-77.8506	-70.1652
Day14	-79.5884	-77.817	-70
Day15	-79.6267	-77.5556	-69.9965
Day16	-79.7031	-77.9931	-70.684
Day17	-79.7326	-78.1285	-70.8819
Day18	-79.3813	-78.0295	-70.3715
Day19	-79.3403	-77.9653	-71.5226
Day20	-75.9704	-73.9861	-75.0122
Day21	-75.8066	-78.4495	-71.2213
Day22	-73.7587	-76.0972	-69.5972
Day23	-73.5799	-75.6302	-69.0017
Day24	-73.2465	-75.5972	-70.408
Day25	-74.2934	-75.7014	-70.6215
Day26	-76.0608	-76	-79
Day27	-76.1997	-76.184	-79
Day28	-100.86	-100.187	-101.253
Day29	-115	-115	-115
Day30	-115	-115	-115

In this research work we compared the signal strengths of the Test mobile networks using ITU-R SINPEMFO code with emphasis on signal strength in decibels as follows [20]:

- -50 to -75dBm → High Signals
- -76 to -90dBm → Medium Signals
- -91 to -100dBm → Low Signals
- -101 to -120dBm → Poor Signals

The closer the number is to 0, the stronger is the signal strength. In other words, the lower the number, the better the signal. For instance, -65 is better than -85.

Because the aim of this work is to access signal strength, our interest from table 1 lies on the RSS values. Table 4.3-4.5 show the percentage frequency distribution of the signal strength of each network operator as generated from Table 4.2 and based on ITU-R SINPEMFO code. The tables give us an overview of the performance of these networks and how effective they are. It also reveals the network that is better designed and ones that require optimization.

The frequency tables formulated based on the above classified range of signal strength in decibels for each network and the corresponding pie chart drawn with them are as shown below:

Table 4.3: Frequency distribution table for operator X

Signal Strength (*dBm*)	Frequency Distribution	Frequency (*%*)
-50 t0 -75(High Signal)	4	13.33
-76 to 90(Medium)	23	76.67
-91 to -100(Low Signal)	1	3.33
-101 to -120(Poor Signal)	2	6.67
Total	30	

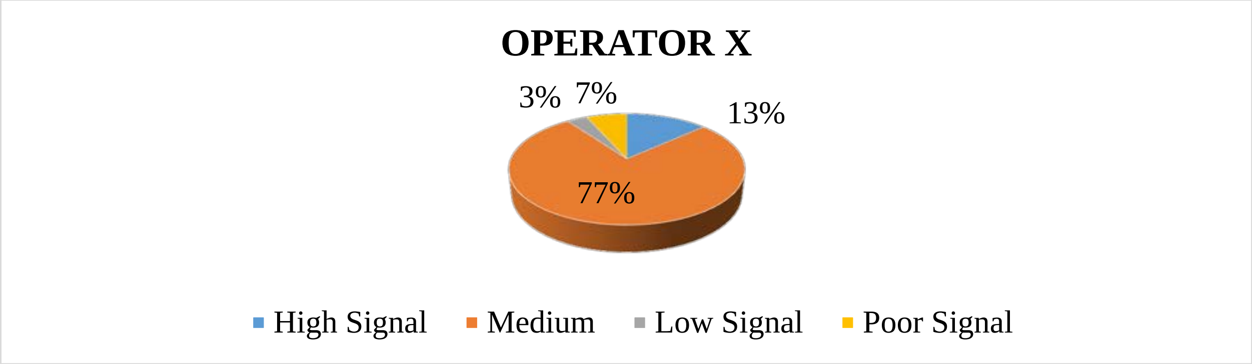

Figure 4.1: Graphical illustration of signals strength of operator X in percentages.

Pie chart of Figure 4.1 shows the percentage distribution in range of signal strength of operator X. The figure depicts that operator X has 13% of high signals, 77% of medium signals, 3% of low signals and 7% of poor signal.

Table 4.4: Frequency distribution table for operator Y

Signal Strength (*dBm*)	Frequency Distribution	Frequency (*%*)

-50 t0 -75(High Signal)	0	0
-76 to 90(Medium)	27	90
-91 to -100(Low Signal)	1	3.33
-101 to -120(Poor Signal)	2	6.67
Total	30	

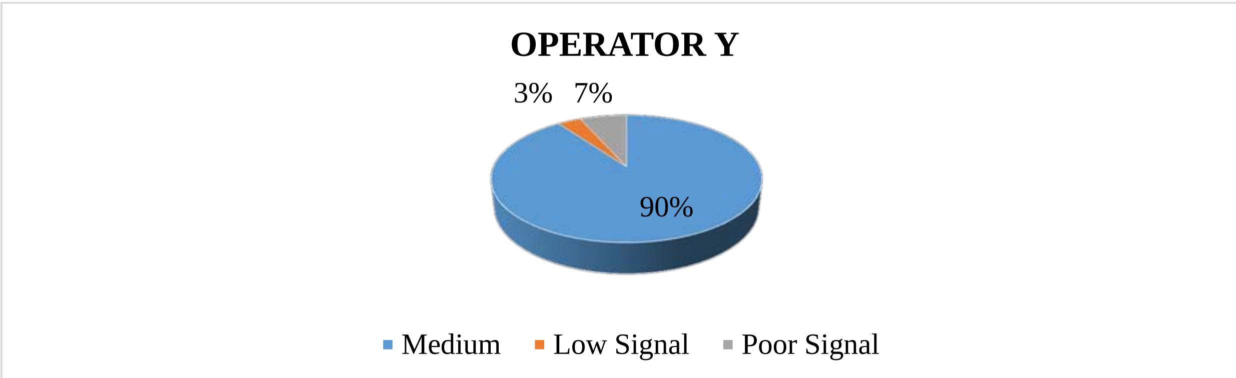

Figure 4.2: Graphical illustration of signals strength of operator Y in percentages.

Figure 4.2 shows that operator Y has 90% of medium signals, 3% of low signals and 7% of poor signals.

Table 4.5: Frequency distribution table for operator Z

Signal Strength (*dBm*)	Frequency Distribution	Frequency (*%*)
-50 t0 -75(High Signal)	23	76.7
-76 to 90(Medium)	4	13.33
-91 to -100(Low Signal)	0	0
-101 to -120(Poor Signal)	3	10
Total	30	

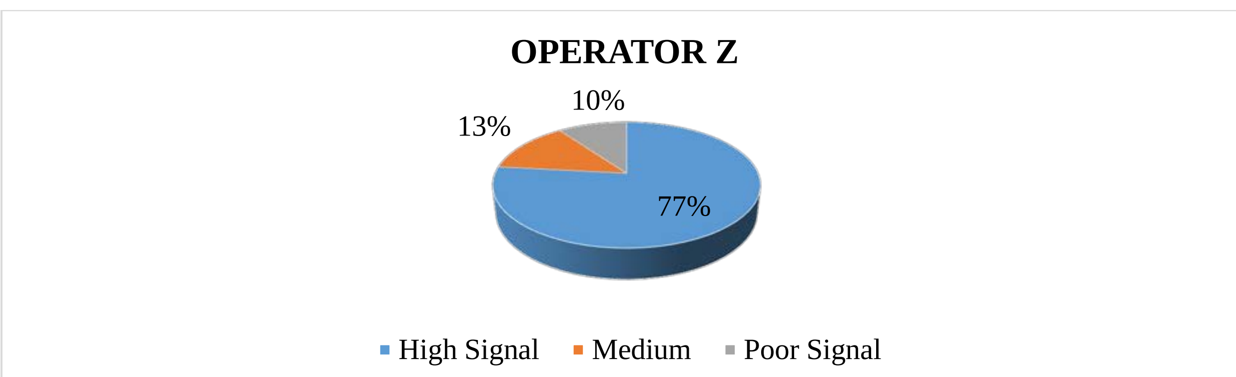

FIGURE 4.3: Graphical illustration of signals strength of operator Z in percentages.

IJISET - International Journal of Innovative Science, Engineering & Technology, Vol. 6 Issue 4, April 2019
ISSN (Online) 2348 – 7968
www.ijiset.com

While figure 4.3 shows that operator Z has 77% of high signals, 13% of medium signals and 10% of poor signals.

Figure 4.4 is the excel-plotted graph of each network signal strength versus day, it shows the variation of signal strength in *dBm* of each network provider per day. From the graph, it can be deduced that there are constant variations in the signal strength of these network providers which may be as a result of factors such as proximity to any obstructions like buildings, mountains or trees etc. The graph is in conformity with the pie charts, it follows that operator Z is at the utmost having the greater number of high signals, followed by operator Y and lastly operator X. It is also observed that operator Z has greater percentage of poor signal compared to the other two operators.

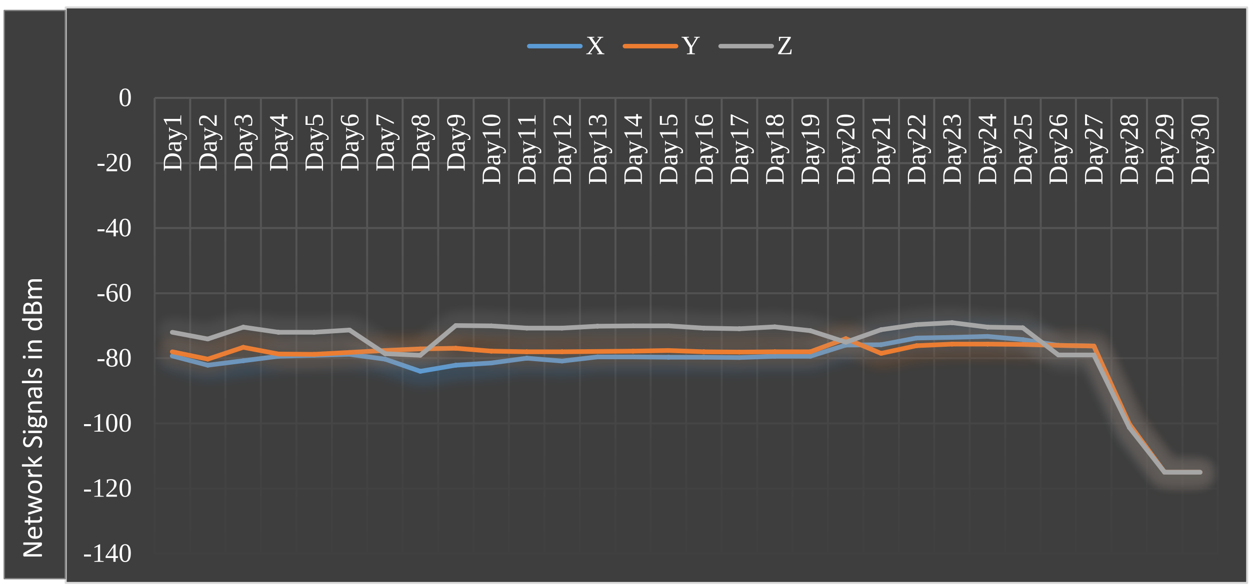

FIGURE 4.4: GRAPH OF NETWORK SIGNALS IN *DBM* PER DAY FOR EACH NETWORK PROVIDER.

5. CONCLUSION

From our assessment, the result indicate that operator Z has better signal strength, followed by operator Y and then operator X. But operator Y has better steady signals compared to the other two, which entails that it is better designed. It is to be noted also that from our assessment, these signals provided by these network providers are not strong enough to provide a better service, because the closer to 0*dB* they are, the better. However, the study shows the need for system optimization (i.e increase in the number of base station and standard signal amplifiers to facilitate signal transmission and reception and also to minimize attenuation respectively); in order to improve on the services rendered by these network providers. NCC should enforce a must compliance to standards by these service providers, so that customer satisfaction can be achieved.

REFERENCES

[1] Hillebrand, Friedhelm, ed. (2001): *GSM and UMTS, The Creation of Global Mobile Communications*. John Wiley & Sons. ISBN 978-0-470-84322-2.

[2] Popoola, J. J. Megbowon, I. O. Adeloye V. S. A (2009): Performance Evaluation and Improvement on Quality of Service of Global System for Mobile Communications in Nigeria. *Journal of Information Technology Impact (JITI), Vol. 9, pp. 91-106.*

[3] Codebreaker Karsten Nohl (2011): Why Your Phone Is Insecure By Design". *Forbes.com*.http://www. forbes.com/sites/ andy Greenberg /2011/08/12/code breakerkarsten-nohl-why-your-phone-is-insecureby-design/

[4] Redl, Siegmund M.; Weber, Matthias K.; Oliphant, Malcolm W (1995): *An Introduction to GSM*. Artech House. ISBN 978-0-89006-785-7.

[5] Redl, Siegmund M.; Weber, Matthias K.; Oliphant, Malcolm W (1998): *GSM and Personal Communications Handbook*. Artech House Mobile.

[6] ASU Wert- Signal Starks messen und interpretieren [ASU parameter measure and interpret signal strength] (in German).

[7] Figures, Joao; Frattasi, Simone (2010). Mobile positioning and Traccking: From conventional to cooperative Techniques. Jone Wiley and sons ISBN 1119957567.

[8] Joshua Bardwell "The Truth About 802.11 Signal and Noise Metrics" A Discussion Clarifying Often-Misused 802.11 WLAN Terminologies.

[9] Baker, A, and Kim-Sung, K (2003). Washington, DC: AARP Public Policy Institute.

[10] Harris Interactive. (2003). Customer satisfaction data. Retrieved, May 21, 2003, from <<https://harrisinteractive.com/.>>

[11] Power, J. D., and Associates. (2003). Wireless network quality assessment study™. Retrieved November 11th, 2004, from <<http://www.jdpower.com/studies/pressrelease.asp?StudyDD=891>>

[12] Stat/MDR. (2003, April). Cellular carrier satisfaction survey. Retrieved June 17, 2004, from <<http://www.instat.com/panels>>

[13] Fajewonyomi, T.E (2007). A comparative study of the network performance of GLO and MTN in Nigeria.

[14] Omorogiuwa, O, and Edeko, F.O (2009).Investigating and modelling of power received at 1800MHz in a mountainous Terrain: A Case study of Igara in Edo state, Ajaokuta and Okene in kogi state ,Nigeria. International journal of Electrical and Power Engineering. 3(3):129-135.

[15] Olasunkanmi, F.O, Segun, I.P, Abolade, R.O, and Oluwole, A.A (2014).Comparative Analysis of Received Signal strength prediction models for Radio network planning of GSM 900MHZ in Illorin, Nigeria.

[16] Nsikan N; Oluyinka O. O; Ibinabo B (2016): Analysis of Mobile Networks Signal Strength for GSM Networks. WCECS Vol.1.

[17] K.H.Kaltbeitzer: technical Monograph 3104, EBU Technical centre, 1965, p.24

[18] Mirabito, m; Morgenstern, B (2004). Satellites: Operations and Applications. The New Communication Technologies (5 ed.). Burling: Focal Press. ISBN 978-0240805863.

[19] Howard W. Sams Co. Inc: Reference data for Radio Engineers, ISBN 0-672-21218-8, p.27

[20] "ITU-R_{SM}. 1135, SINPO and SINPFEMO codes".