

Multibeam RF Antenna Performance for Indoor Coverage in Stadium

Suzi Seroja Sarnin, Mohd Yusdee Yusoff, Mohamad Yazid Mohamad,
Nani Fadzlin Naim, Norsuzila Yaacob

Faculty of Electrical Engineering, University Technology MARA, 40450 Shah Alam, Malaysia

Article Info

Article history:

Received Jan 7, 2018

Revised Mar 10, 2018

Accepted Apr 19, 2018

Keywords:

RF Antenna

ABSTRACT

The objective of the proposal is to address the demand on data over the services provided by telecommunication industries during major events held in Malaysia especially in stadiums. Previously, during most of the events, users will experience bad services in both data and voice transactions. It is not only slow or delayed but almost failed to access the network to connect them to the world. Besides a few solutions that have been introduced such as IBC (In-Building Coverage) and Small Cells, this proposed solution Multibeam RF Antenna, is one of them to address the demand. This solution has been chosen as it is fast in deployment, easy to maintain and cost effective even if it may not cover the whole targeted areas.

This paper will provide analysis, evaluation and actual Walk Test (WT) to show the effectiveness of the Multibeam RF Antenna.

Copyright © 2018 Institute of Advanced Engineering and Science.
All rights reserved.

Corresponding Author:

Suzi Seroja Sarnin,
Faculty of Electrical Engineering,
University Technology MARA, 40450, Shah Alam, Malaysia.
Email: suzis045@salam.uitm.edu.my

1. INTRODUCTION

Nowadays, demand in mobile applications escalates rapidly day by day. Almost 50% of the Malaysia populations have mobile phones that are used to communicate. Data transaction activities are at higher statistics compared to voice call communication.

Subscribers are most likely to update their status over the Internet and would rather communicate via applications such as WhatsApp, Facebook (FB), and Instagram (IG) etc. Hence the demand is critical if the telecommunication network services cannot support the demand and needs.

During big or major events with large of crowds, data transactions are crucial as subscribers preferred to update their status “live” and they also expect to be updated by their friends “live” as well.

As all users notice on the limitations of the facilities around them, telecommunication companies must take an initiative to serve their customers well.

The case study of this paper will be focusing on addressing the subscribers’ demand in a stadium (Stadium National Bukit Jalil) during a major event (SEA GAMES 2017).

Conventional methods that are usually deployed by telecommunication companies in Malaysia via Mobile BTS trucks have limited resources and are less cost effective too. The Multibeam RF Antenna solution is faster way in deployment, practical in serving a big crowd, more cost effective and easy to maintain.

2. METHODOLOGY

A comparison is made between the normal method of deploying the eNodeB/NodeB with Antenna Feeder System (AFS) and the new proposed Multibeam RF antenna. In normal situation, one eNodeB/NodeB

will have 3-unit of RF Antenna and the azimuth of the antenna will be arranged in 3-sectors with each beam occupying the azimuth ranging from 0⁰ to 120⁰ and it will form 360⁰ coverage of each site.

Hence, each of the targeted area will be served by 1-sector antenna and the resources will be fully utilized at 33.33%. By introducing the Multibeam RF Antenna solution, all the resources of the eNodeB/NodeB will be fully utilized and subscribers/users will enjoy the fast throughputs to be connected to the Internet and apps as well as voice calls.

The application of this Multibeam RF Antenna, will only focus on High Band (HB) spectrum where the bandwidth allocated by MCMC is wider and the selected frequencies (HB) are more effective compared to Low Frequency (LF) bands.

The antenna specification is defined by the manufacturer and the most critical items to be considered is the antenna Gains and the beam forming for both Horizontal and Vertical values.

The frequencies and technologies used are as below in Table 1.

Table 1. Frequency Spectrum and Technologies

Cellular Mobile Services

Systems		Lower Frequency Limits	Upper Frequency Limits
CDMA 450	(Base Rx)	452.000 MHz	456.475 MHz
	(Base Tx)	462.000 MHz	466.475 MHz
EGSM/GSM	(Base Rx)	880 MHz	915 MHz
	(Base Tx)	925 MHz	960 MHz
	(Base Rx)	1 710 MHz	1 785 MHz
	(Base Tx)	1 805 MHz	1 880 MHz
IMT	(Base Rx)	825 MHz	835 MHz
	(Base Tx)	870 MHz	880 MHz
	(Base Rx)	880 MHz	915 MHz
	(Base Tx)	925MHz	960 MHz
	(Base Rx)	1 710 MHz	1 785 MHz
	(Base Tx)	1 805 MHz	1 880 MHz
	(Base Rx)	1 920 MHz	1 980 MHz
	(Base Tx)	2 110 MHz	2 170 MHz
	(Base Rx)	1 980 MHz	2 010 MHz
	(Base Tx)	2 170 MHz	2 200 MHz
	(Base Rx)	2 500 MHz	2 570 MHz
	(Base Tx)	2 620 MHz	2 690 MHz
TDD	1 885 MHz	1 920 MHz	
TDD	2 010 MHz	2 025 MHz	
TDD	2 570 MHz	2 620 MHz	

Note: TDD -Time Division Duplex

3G-UMTS

4G-LTE-FDD

4G-LTE-TDD

The proposal will be using by 4-telecommunication industries namely Celcom, Digi, Maxis and Umobile (CDMU). These operators are chosen because they are the existing players of 3G-UMTS & 4G-LTE as well as major subscribers' shareholder in Malaysia.

Their services will be combined together using the combining circuit called Hybrid Coupler and Triplexer. With this combination, the telecommunication industries will be limited to deploy the LTE-1800 services as it will create the intermodulation interference. In order to accommodate multi operator i.e. CDMU (Celcom, Digi, Maxis, Umobile), the design of circuit combining is required. The proposed combining circuit are as below.

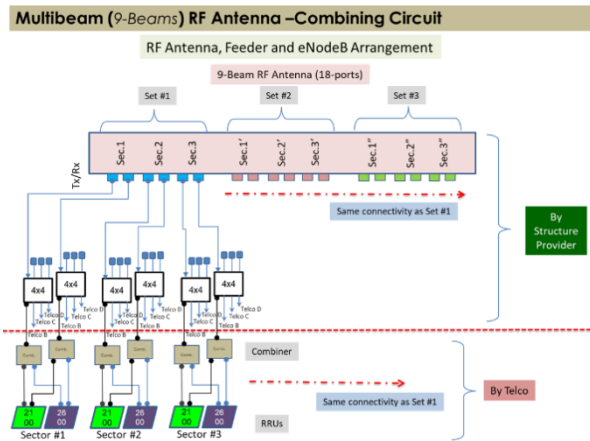


Figure 1. RF Antenna and Combining Circuit

The combining circuit is critical part of the project as it introduces the power loss which will involve the performance such as signal strength penetration and interference. It is also cost effective where the more the combiner used the more it cost the solution. The deployment of the circuit is also crucial as it involves wiring and orderliness to avoid mistakes in connectivity to the active elements i.e. NodeB(3G) or eNodeB(4G). These NodeB and eNodeB are known as active elements because it needs electric power to turn it ON. The numbers of these

NodeB/eNodeB are limited to maximum of 6-units per operator i.e. 3xNodeB and 3xeNodeB. The Operator) can set their own target objective such as throughput speed of their subscribers. The lower the throughput setting the more subscribers can be served by their equipment (NodeB/eNodeB). Level of congestion can be monitored via a system controller and operator(s) may control their network setting based on subscribers’ behaviour. If the utilization is low, the operator may allow the throughput speed to be faster and vice versa.

Below is the simulation of Multibeam RF Antenna to be deployed in the stadium. 2-units of antenna is used to serve inside the stadium and each antenna beam width only covers half of the stadium with beam opening at ~45 degree. In order to serve subscribers in the stadium, the position of these 2-antenna will be located at both ends and the azimuth will be at opposite angles in order to avoid overlapping coverage. The overlapping coverage is not recommended and is to be avoided as it will affect the service performance. The coverage served by these antennas is determined after the active elements (NodeB/eNodeB) are turned ON. It will be verified via the Walk Test (WT) activity. Coverage spillage from outside cells is also another challenge to be considered and it also contributes to the quality performance. In this case, site re-engineering is required to be done in order to ensure subscribers are free from bad quality experience.

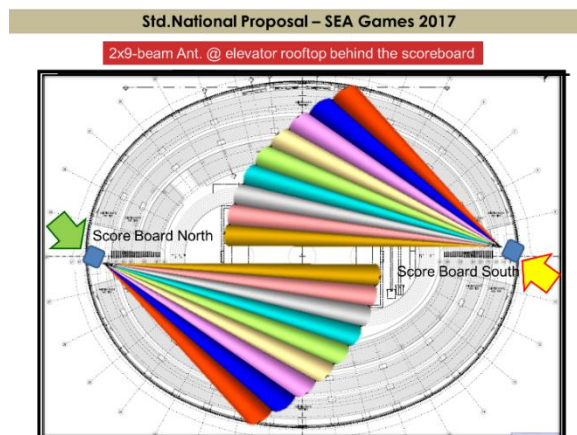


Figure 2. RF Antenna Targeted Serving Area via Beam Performing

The proposed location of the Multibeam RF Antenna is another challenge to be considered. The designed shall be based on effectiveness, feasibility, future proof and cost effectiveness. Figure 3 shows the proposed location of Multibeam RF Antenna to serve the surrounding area of stadium. The direction of the antenna must not be blocked by any obstacle(s) in front of the panel antenna.



Figure 3. RF Antenna Proposed Location in Stadium

Most of spectators’ area will be served by these antennas. However, the blind spot area i.e. under the concrete sitting location will be unlikely served as signal may not pass through the concrete wall. Coverage enhancement for the blind spots area will be served via another solution such as Small Cells or Repeater.

The proposed Multibeam RF Antenna shown in Figure 4 is custom made to address the demand. The antenna beam width is rather small as to accommodate multi numbers of NodeB/eNodeB in order to cater the capacity requirement during the event.

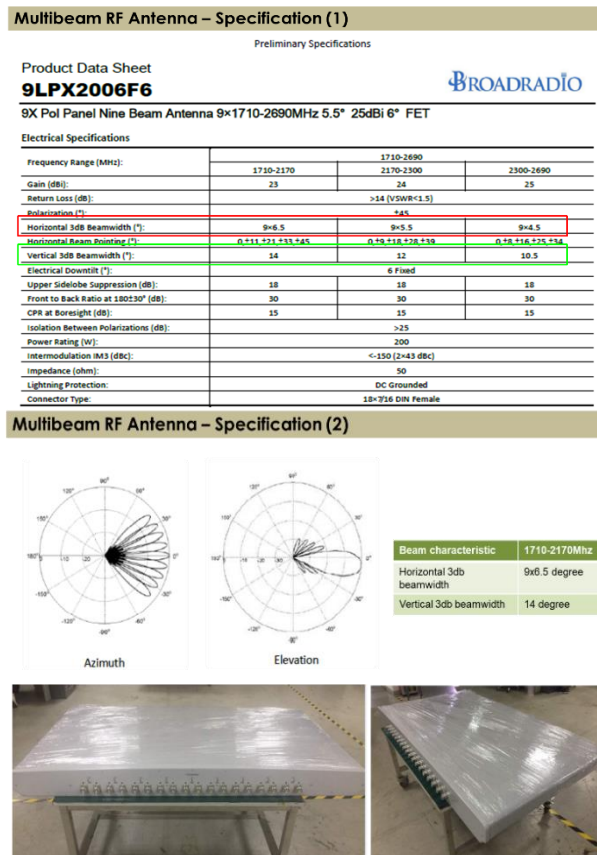


Figure 4. Multi Beam RF Antenna Specification

Since the focus is more on 3G and 4G systems, the statistics to be monitored and compared before and after event are as below.

1. Walk Test (WT) – Drop Call & PCI Code detection
2. Statistics : Resource Block (RB) Utilization
3. Statistics : Cell Availability
4. Statistics : RSSI(4G-LTE) & RTWP(3G-UMTS)
5. Statistics : RSRP(4G-LTE) & RSCP(3G-UMTS)

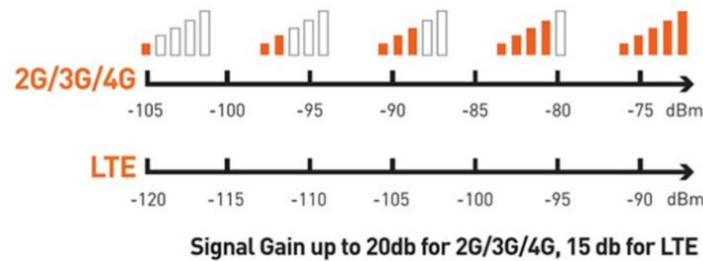


Figure 5. Benchmark of Coverage Strength

In the Universal Mobile Telecommunications System cellular communication system, received signal code power (RSCP) denotes the power measured by a receiver on a particular physical communication channel. It is used as an indication of signal strength, as a handover criterion, in downlink power control, and to calculate path loss. While in the LTE, Reference Signals Received Power (RSRP) is a measurement of the received power level in an [LTE](#) cell network.

3. CONCLUSION

The performance of the Multibeam RF Antenna can be monitored by the statistics produced by the telecommunication industries. The optimization of the network quality shall be performed by re-engineering the Antenna via panning and mechanical tilt. The Walk Test (WT) shall be applied once the re-engineering activity has been performed.

Performance on cell utilization and throughput are to be considered by individual telecommunication industry as they need to have their own forecast towards the targeted attendance. The throughput is subject to telecommunication industry's equipment configuration such as CE (Channel Elements) cards, target of subscribers throughput speed.

Among the statistics to be considered are Cell Utilization that shows the congestion level, RSSI (4G-LTE) and RTWP (3G-UMTS) as indicator for the interference level, RSRP (Reference Signal Received Power) and RSCP (Received Signal Code Power) as indicator on coverage strength. These measurements are used as a benchmark of the network quality of each telecommunication industry. Parameter Setting and Configuration of each telecommunication industries will be different and subject to the throughput target set for their subscribers.

The design shall consider the future requirements such as 4T/4R, LTE1800 deployment and an addition of other telecommunication industry to join in serving their subscribers inside the stadium.

Overall conclusion, the design is feasible and cost effective as compared to other solutions. Other elements such as backhaul and fronthaul connectivity as well as sharing power system are another option to be considered towards cost saving and easy maintenance.

Acknowledgement

The authors wish to thank members of Faculty of Electrical Engineering, Universiti Teknologi MARA Shah Alam, Malaysia for the guidance and support during this project. This research was supported by "Fundamental Research Grants Scheme", file No. 600-IRMI/FRGS 5/3 (099/2017 and Minister of Higher Education.

REFERENCES

- [1] Varadan, V.K., Vinoy, K.J. and Jose, K.J. 2002, "RF MEMS and their Applications", John Wiley & Sons
- [2] De Los Santos, H.J. 1999, "RF MEMS Circuit Design for Wireless Communications", Artech house.
- [3] Balanis A.1982, "Antenna Theory Analysis and Design", John Wiley & Sons, New York.
- [4] Joseph C. Liberti, Theodore S. Rappaport, 2012, "Smart Antennas for Wireless Communications: IS95 and third generation CDMA Applications", Prentice Hall, Communications Engineering and Emerging Technologies Series.
- [5] Mathew M.Radmanesh, 2001, "Radio Frequency and Microwave Electronics", Pearson Education Asia edition.
- [6] Product Catalogue of BroadradioCo.Ltd.