Empirical study on New Base Transceiver Station installation For 4G

By

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This Internship Report is presented in partial fulfillment of the requirements of the Degree of Bachelor of Science in Electronics and Telecommunication Engineering

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UNIVERSITY DHAKA-1207, BANGLADESH

December, 2018

Certificate of Training

Industrial attachment on Telecommunication Hardware installation & commissioning (3 Months)

This is to certify that

SHAMSUZAMAN SHAMIM Son of NOOR MOHAMMAD BHUYIA

Under Internship ID: SLI_0011

Successfully completed the above course.

Signed: .....

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APPROVAL

This Internship Report Titled **"Empirical Study on New Base Transceiver Station Installation for 4G"** is submitted by Shamsuzzaman Shamim to the Department of Information and Communication Engineering, Daffodil International University, has been accepted as fit for the partial fulfillment of the condition for the Degree of BSc (Hon's) in Electronics &Telecommunication Engineering & approved as to its style and guts. The Presentation will be held on January, 2019

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DECLARATION

I hereby declare that this Internship Report has been done by me under the supervision of **Engr. Md. Zahirul Islam**, Assistant Professor, Department of ETE, Daffodil International University & Starlink Engineering Limited. I also declare that neither this report nor any part of it has been submitted away for award of any degree.

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ACKNOWLEDGMENTS

At First, I am like to convey my gratitude to the Almighty for charitable me the right path while trying the duty.

The real sprit of achieving a goal is finished the way of quality and austere castigation. I would have never thrived in effecting my task without the teamwork, help and support provided to me by many personalities.

This internship report would not consume been possible without the provision and direction of **Engr. Md. Zahirul Islam, Assistant Professor,** Department of Information and Communication Engineering, Daffodil International University, Dhaka, under whose direction I chose this topic.

I would like to rapid my heartiest gratitude to **Md. Taslim Arefin, Associate Professor and Head,** Department of Information and Communication Engineering, for his kind help to surface our thesis and also to other faculty participants, the staffs of the ICE Department of Daffodil International University.

I must grant with due esteem the perpetual support and endurance of my family members for final this internship.

Shamsuzzaman Shamim

Abstract

Base transceiver station (BTS) support multiple conversation with mobile station on different frequencies, each carrier signal must be amplified separately. It is possible to provide a signal power amplifier for each carrier, along with a frequency selective combiner. In the report, a new BTS installation process is described for 4G in order to provide more coverage by with best deal and best cellular technologies like 3Gor 4G. To install a new BTS, some indoor and outdoor equipment id needed which is studied empirically and mentioned their role in this report. Introduction of GSM antenna, microwave antenna, different types of transmission cars is addressed empirically.

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Chapter1

Introduction

1.1 Introduction

This paper contains what is telecommunication? Telecommunication system, types of cellular network generation. What is base transceiver station. How is install new base transceiver for 4G cellular network. telecommunication define as transmit and receive all type of data like voice information, video information data etc over significant distances by cellular network. To transmit and receive information in telecom system use different type of media like cable which can be optical fiber, different types of wave with different frequency wave must be electromagnetic wave. BTS full form is base transceiver station. BTS provide connection between mobile user and mobile operator. Bangladesh mobile operator are GP, Robi, Airtel, teltalk. To communicate properly have to communication technologies like GSM. CDMA in Bangladesh basically use GSM also have other communication method like Wi-Fi, LAN, WAN, WiMAX. BTS is basically install for GSM system. New Base Transceiver Station install for cover that area where no network is existing before. Increase the network coverage to connect more user or MS to the network.

1.2 About Starlink Engineering Limited.

Starlink Engineering Limited is an Engineering servicing company providing full scope of engineering services like initial Site Survey, Planning, Installation, Commissioning, Operation and Maintenance as well as network optimization in the field of Telecommunication and Info-rmation Technology. Starlink Engineering Limited was started in 2008 by a group of young and passionate Engineering Team to partnership with different vendors, Telecom operators and corporate enterprises in Bangladesh. Starlink Engineering Limited was established in 2008. Company have won many Achievement awards over the years, most recently the 2011 Excellent Development Award in GP Swap Project from the Huawei Technologies (Bangladesh) Ltd. These complement similar awards in 2007, 2009 and 2010.

1.3 Company Profile

Name	**: Starlink Engineering Limited.**
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Telephone	**:** +88029862208
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Website	**:** http://www.starlinkengineering.com

1.4 Environmental health and safety

Star Link understands the risk involved in working onsite. Hence it is our top most priority to ensure proper security and precautions for the employees.

Star Link strongly maintains the rules and regulations for on-site technical persons. Also, Star Link is committed to its customer as well as its employees to provide them all the safety manuals and materials while working.

StarLink proudly announces that at the beginning of this year a board meeting decides that following are the key safety precautions that all the employees must follow during work

- All the employees must use Helmet while working in BTS/MW or Tower sites
- All the employees must use SHOES while working
- All the employees must use SFETY BELT while working on TOWER
- All the employees must use HAND GLOVES while working
- All the employees must be educated or informed enough so that they can understand and oblige by any safety requirements that are imposed by the CUSTOMER
- All the employees must not wear any metallic or conductive equipment's while working on power materials

- Concern persons must arrange meeting or training in each 3 months or beginning of a major project to train the employees about maintaining the safety and quality of installation and commissioning
- Consecutive breach of safety regulations will result in punishment or termination of any employee.

1.5 Objective of the Report

The main objectives of this report are as follows:

1. Cellular network: GSM System.
2. Types of cellular network technologies.
3. New BTS installation for 4G

1.6 Summary of the Report

The objective of this Internship is to improve an effective knowledge in Subcon in Sterlink Engineering limited. In ***The First chapter,*** I have termed the Details & objective an overall view that I am going to instrument during this internship work and I would describe the background of sterlink Engineering Limited. company EHS rule.

The Second Chapter, Cellular System and GSM Technology

The Third chapter is describing, Cellular network generation

The last one is Chapter ***Four*** that is BTS installation for 4G and

Chapter five Conclusion.

Chapter 2

Cellular System and GSM Technology.

2.1 Cellular System

The cellular is a base on wireless communication method all communication done with wireless system. Its distributed its network in fixed area with base transceiver station (BTS). All base transceiver station has a basically 3 cell like A cell, B cell, C cell, point at different angle. To help of base transceiver station coverage some network area of fixed distance and transmit information like data, voice, video. For video type information have to use 3G or 4G which provide by service provider. Every service provider uses different range of frequency to ignore interference, crosstalk, attention also for high quality cell services. That offer high number of portable transceivers to connect with each other can communicate anywhere which in the network area by the base transceiver stations. in cellular network provide some features:

- User devices power consumption is less when its single transmitter or user devise have strong signal.
- Its offer frequency reuse.
- Its use horizon cell so there is no gab between 2 or 3 cells.
- Also, can splits the cell or add the cell to increase the capacity.

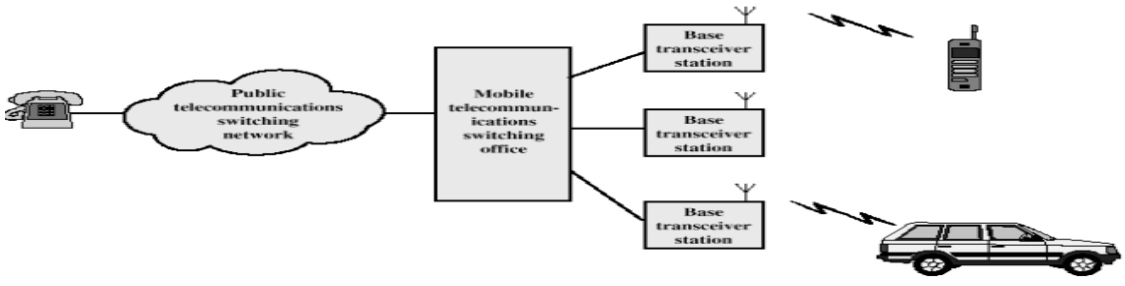


Fig 2.1 Cellular system

2.2 What is cell?

- Larger area divided into small no.of area.
- Shape is hexagonal.
- Each with its own base station and set of frequencies.

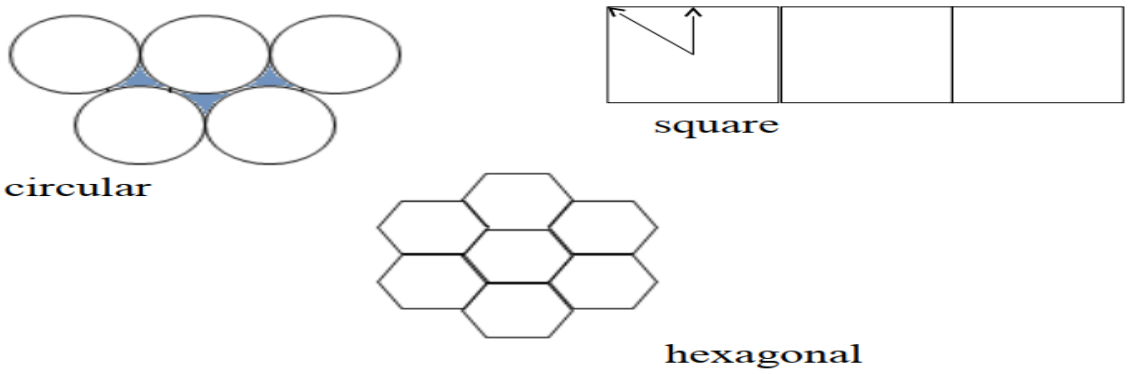


Fig 2.2 Cell

Small cells, which have a smaller coverage area than base stations, are categorized as follows:

- Microcell range 2 km
- Picocell range 200 m
- Femtocell almost 10 m

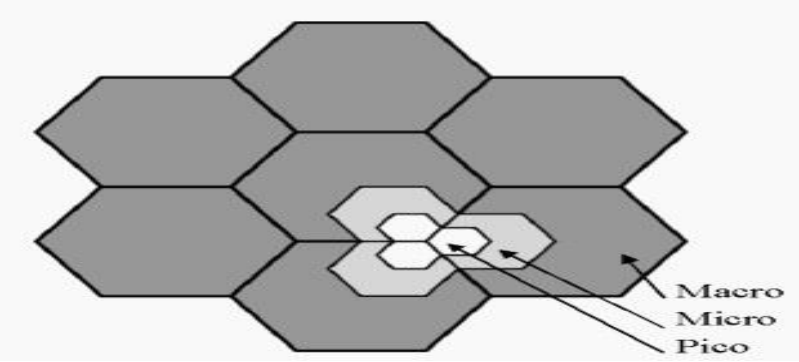


Fig2.3 Small Cell

2.3 Concept

Cellular system also defined as or known as cellular radio system. That can offer radio service which divide into cell with specific way that depends on reception and terrain characteristics. That builds on square, circular, regular shapes and hexagonal. In hexagonal shapes there is no gab. So no less is occurs in hexagonal cell. Every cell is allocated with multiple frequencies that had corresponding radio base station. Capable of reuse fix set of frequency can use in the other cell. Have to ensure that same set of frequencies are not reused in the neighboring cell other than it's occurs interference, crosstalk, noise. Can also increase the capacity of cellular network system without install new base station by use same method which is cell splitting in this prosses cell divided in to 2 cell or by the cell addition. Amosjoel of bell developed the mobile switching system which provide multiple callers on that same area to use the same set of frequency by switching calls made using that same set of frequency to the close to the available base transceiver station tower having that frequency available and from the fact the same set of radio frequency that must be reused in a different area for a completely different transmission. In single plain type of transmitter. Only one transmission has to use on any given frequency. But must be inevitably some level of interference from the signal from the different cells that can be use the same set of frequency.1st commercial cellular network technologies launched in japan by Nippon Telegraph and telephone in 1979 which is 1G.

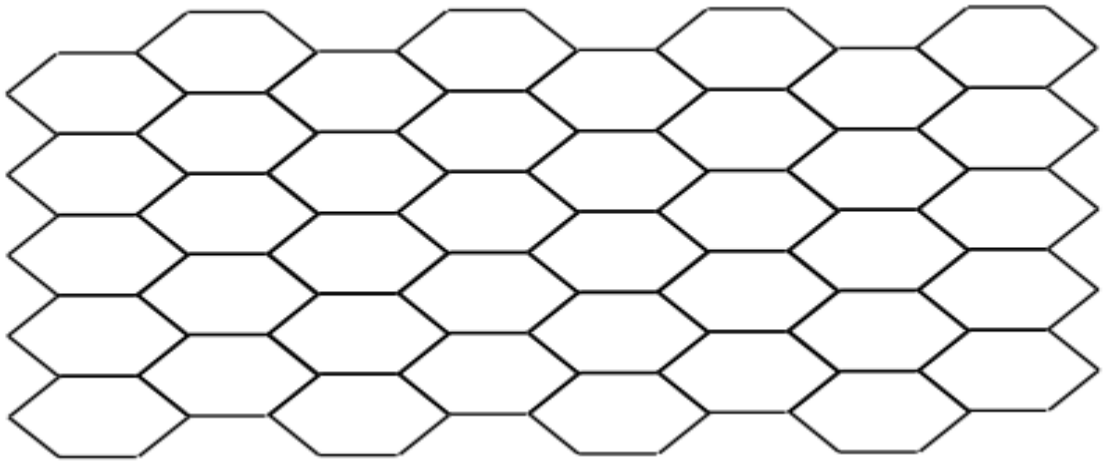


Fig2.4 Cellular Concept

2.4 Frequency Reuse

In the frequency reuse, use the same frequency aging and aging to avoid the miss use of frequency. Frequency reuse procedure become easier with hexagonal cell shape. In GSM system frequency reuse factor is 1/K. In CDMA its 1. Config cells to assigned different frequencies to avoid interference or crosstalk. Basically, frequency reuse in closer cells. Minimum 10 to high 50 frequency allow for each cell.

Cellular system on of the beauty or most important part is frequency reuse. That Increase the cellular system coverage and capacity without add extra base transceiver station. Frequency reuse in only closer cell which shape is hexagonal. Adjacent cells have to use different frequencies.is the tow cells far ways from to each other than there is no problem to frequency reuse there no tension for crosstalk. This prosses consume the less power. There are 2 things require to observe frequency reuse that is distance D and reuse factor. Now D is obtaining by:

$$D = R\sqrt{3N}$$

R is known as cell radius and N is known as cells per cluster.

Now the frequency reuse factor which is 1/K. In here K is the number of cells that don't use the same set of frequency which use for transmission. Basic number of frequency reuse factor age 1by3,1by4,1by7,1by9 and 1/12. In same BTS site if each of the cell direction is different in case can use same frequency in each of cell. Basically, a base transceiver station has 3 cell which is A cell, B cell, C cell. Each cell allows to use a number of frequency channels corresponding to the bandwidth of B/K. Where B is available bandwidth. In same way each sector can be use bandwidth of B/NK,

Advantage of frequency reuse:

- Require low bandwidth.
- Minimize the number BTS
- Low cost and maintenance so easy.

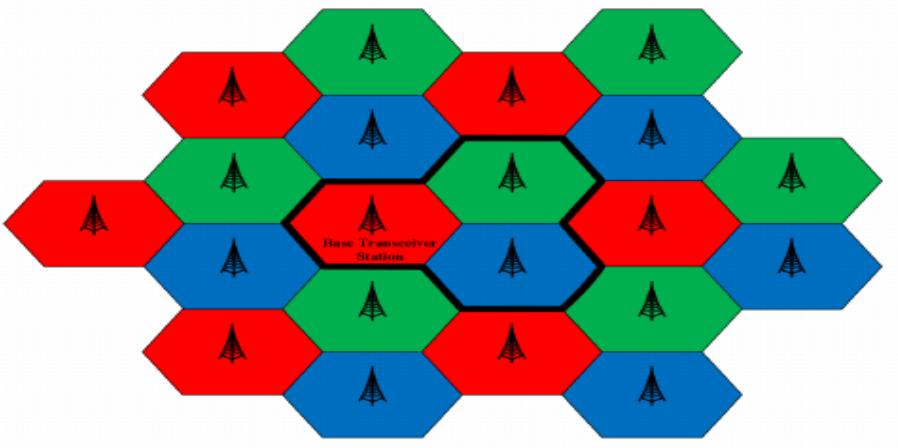


Fig2.5Frequency Reuse

2.5 Handoffs (typically 30 mseconds):

Handoffs another important part of cellular network. Basically, user device hand of or control of a on BTS to other BTS. When user get way from the BS recently using BS notice weak signal with user device than user device transmits the under the new BS which signal strong with this BS its call Handoffs. Basically, it occurs when user move one place to another place. Advantage of this technique user device allows connected with strong network. Provide good call quality. Provide high speed internet connection. Disadvantage of system is some handoff not successfully completed occur call drop. Power consumption is high. Probability to a handoff occurs before call termination.

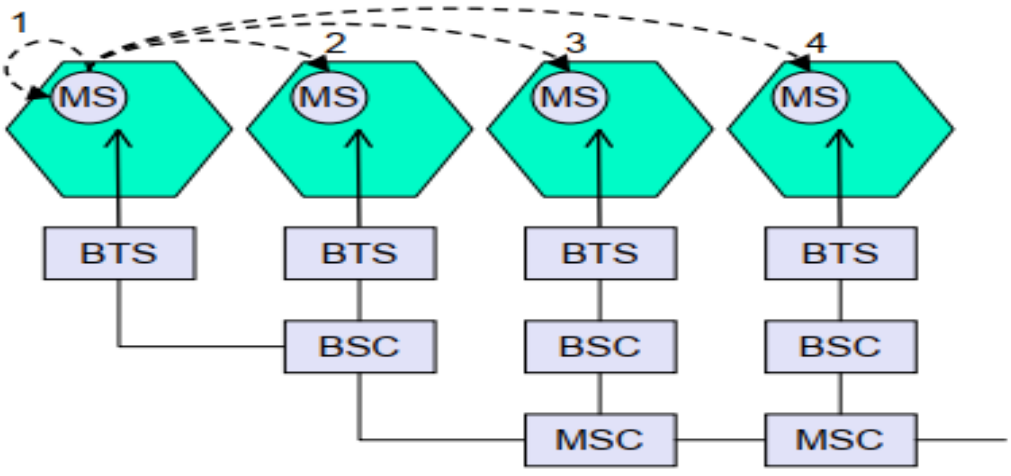


Fig2.6 4 types of handover

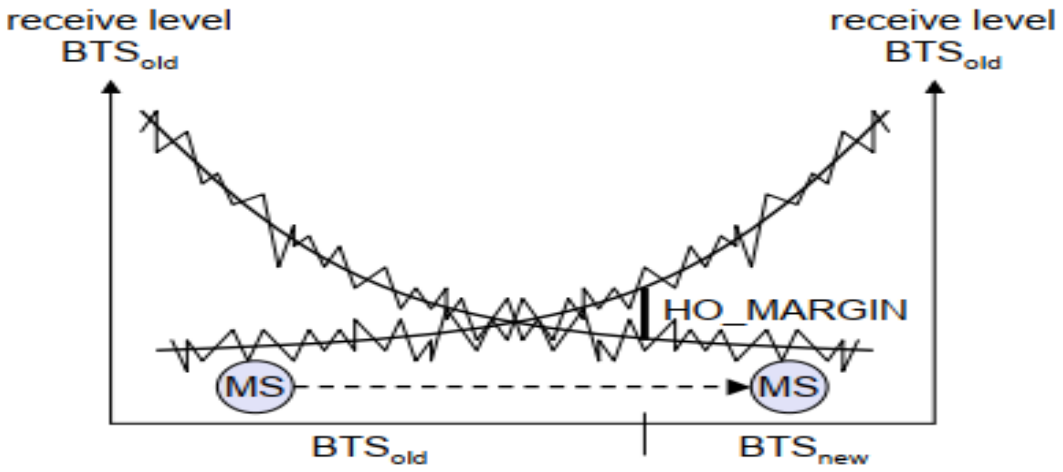


Fig 2.7 Handover decision

2.6 Traffic Engineering

In the telecommunication run analyzing the on network to the find out performance of the network to do that use the method call traffic engineering. In this method monitor the traffic of the network when data transmit over the network. This method also defines as telegraphic or traffic management. In this method identify channels and active subscribers are equal. System of network must be capable of deal with load. There are two types of system:

- L>N=known as blocking system.
- L<N=known as nonblocking.

N is known as user capacity and L is a number of subscribers

1 **Determine the charter of the traffic model**

- Capable of handle call which get block
- Assigned a new channel for the cell which is free.
- Blocked are must be dropped and rejected.
- Have a function of lost calls cleared.
- Also have a function of call held.

T**raffic intensity**

- Load of the system define as:A=yh
- y=unit per time attempted of rate of calls.
- h=call successfully hold par time.
- A=in hold period number of calls arriving.

2.7 GSM (Global System for Mobile Communications)

European telecommunication standards institute the introduce advance wireless mobile communication system which is GSM (Global System for Mobile Communications). GSM is second generation cellular network system. This system uses the circuit switching system to data transport. Than get update it became 2.5G(GPRS) that can provide call plus data services. Then came 2.7G(EDGE) in here improved the data and voice quality. Then UMTS standard introduce the 3G third generation cellular network system. It's also part of GSM technologies. As usual network became 4G and 5G almost ready to run. They all part of GSM system. Bangladesh basically used GSM. CDMA is no more used in BD. All BTS tower are installation for GSM type network. BTS interconnection between user device and service provider like robi, gp airtell, teletalk. BTS user different type of transmission card to transmission for 2G used GMPT. For 3G used UMPT or WMPT. For 4G used UMPT card for transmission.

2.8 GSM system overview

The GSM system run on the method of frequency and time division modulation. Data and voice must be carrier by the frequency carrier and time slot number (TDM). Cellular system are radius the signal with low power by each of BTS cell, Acell,Bcell,cell. Frequency Division Duplex (FFD) use for user uplink and downlink which assigned with different frequencies. For data used Time division access. (TDMA) frame. Easy to say system divided into time slots.

2.9 GSM system architecture

Before build something needs the architecture to build in proper way and what element use to build to right architecture. In cellular system use the same method to build right architecture for cellular network. As same GSM, to create right architecture. To build right architecture of GSM system require same element. GSM is 2G architecture but it's still uses on the cellular network.4G 3G,5G also use that architecture. Can say muster structure of cellular system is GSM architecture. This system was introduced in 1990s and element of this also introduce in this year. Basic element use in system are:

- Mobile station (MS)
    1. User device
    2. Subscriber identity module
- Network switching subsystem (NSS)
    1. Mobile switching center (MSC)
    2. Home location register (HLR)
    3. Equipment identity register (EIR)
    4. Authentication center (AUC)
    5. Visitor location register (VLR)
- Base station subsystem (BSS)
    1. Base transceiver station (BTS)
    2. Base station controller (BSC)
- Operation and support subsystem (OSS or RSS)

In this GSM structure mobile station connected with the base station subsystems then BSS connected with the NSS. Network switching subsystems is connected with the another NSS. The architecture of GSM system given blow:

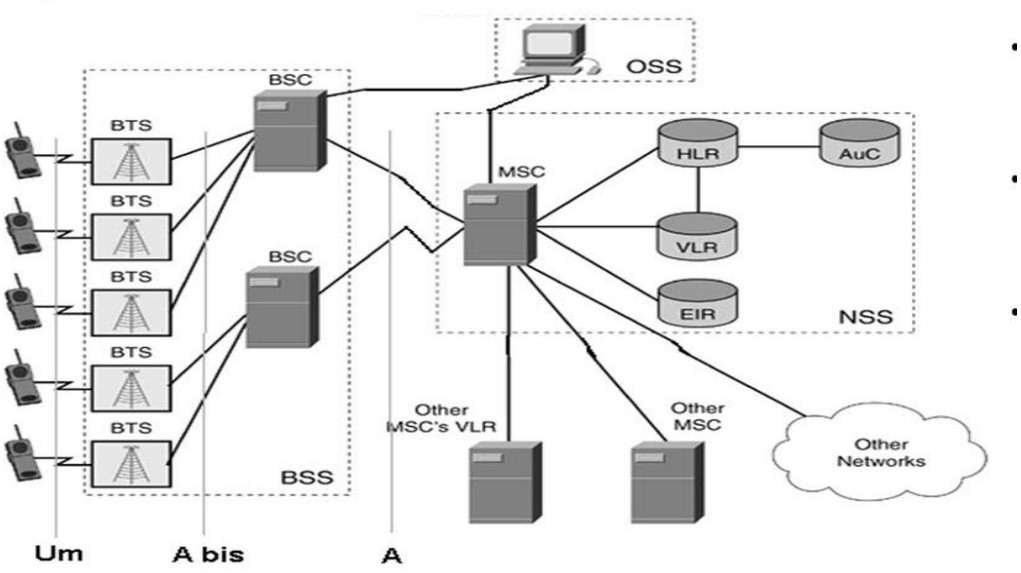


Fig2.8 GSM system architecture

2.10 Mobile station

User device, computer, device which connected with the network are call Mobile station. Basically, is a cell phones other types of device which have sim inside in. User device increased in those year. Mobile station basically connected with the base transceiver station on the BSS. communicate between mobile station and base transceiver station must need SIM. To power the SIM or boost the signal need device which is mobile station or user device. Without SIM and mobile station GSM structure is incomplete.

Fig 2.7 user device

2.11 The SIM

Sin is known as a subscriber identity module. Also call subscriber identification module (SIM). In the SIM a electric cheap build on or can say an integrated circuit inside the SIM. The SIM basically have subscriber or user identity. Can say user information like SIM number which depend of the operator. In Bangladesh first 3 number +088 is Bangladesh code next 3 number is operator identity and last 6 six number for user identity. The cant fun alone needs a device to run which call user device. Without sim card MS is useless. SIM must be needed to complete the GSM structure. A SIM card have few thing or programmer like personal identity (PIN) which given by user. If user forgot the PIN use PIN unblocking KEY (PUK) which given by the operator. Also have mobile station ISDN number (MSISDN), Temporary Mobile Subscriber Identity (TMSI) and if SIM is stolen than have International Mobile Subscriber Identity (IMSI) is can't be change. Also have same security for data like The individual key (Ki), The algorithm for authorization and ciphering and the last one is The Cipher key (Kc).

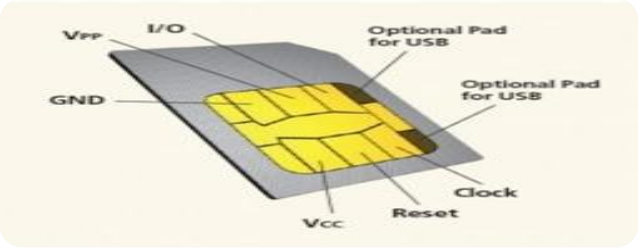


Fig2.9SIM

2.12 Base Station Subsystem (BSS)

After the mobile station GSM architecture have the base station subsystem (BSS) part. Inside this have 2 impotent elements which is base transceiver station (BTS) and Base Station Controller BSC.

2.12.1 Base Transceiver Station (BTS*):*

The base transceiver station (BTS) is a part of BSS in the GSM cellular system. BTS transmit signal in fix area which assigned for it. BTS receive the signal from the MS unit. Transmit the Signal in the MSC in the GSM architecture. Use Um interface to concoction between mobile station unit and base transceiver station. BTS run on commercial power, electrical generator, Soler energy and battery. BTS have 4 type Pole site, green field, roof top, guy mast towers.

2.12.2 Base Station Controller (BSC):

The base station controller is a control unit of the base station subsystem the GSM network. Basically, control base transceiver station. Its switching system between TRAU and base transceiver station. It calculates the error massage of base station subsystem. Its deal with handover on BTS. Abis interface use in the BSC.

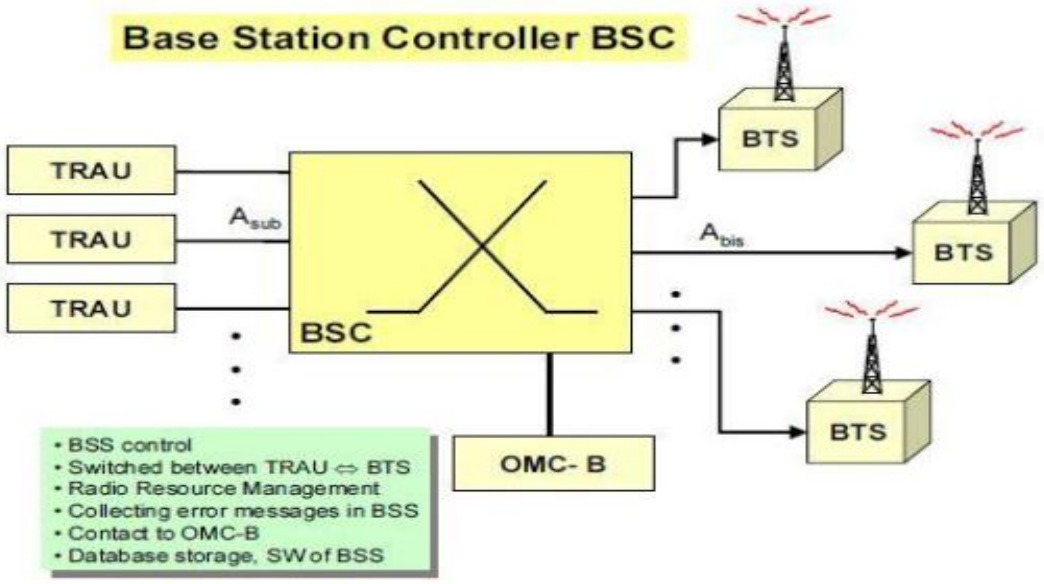


Fig 2.10 BSC

2.13 Network Switching Subsystem (NSS)

Network switching subsystem is one of the most part of the GSM architecture. It's also known as core part of the system. It's have major element of the network which is MSC,HLR,VLR,EIR, AuC etc

2.13.1 Mobile Services Switching Centre (MSC):

Mobile services switching center is the most impotent part and core of the network switching subsystem on the GSM architecture. MSC is a basic switching system work with PSTN OR ISDN. Also fulfill same additional requirements foe user device. Basic part of MSC:

- Registration
- MSC to MSC handover.
- Call location
- Authentication and
- Call routing
- Can call in LAN in help of MSC
- Also call another cell operator

HLR, VLR, EIR interconnect with the MSC.

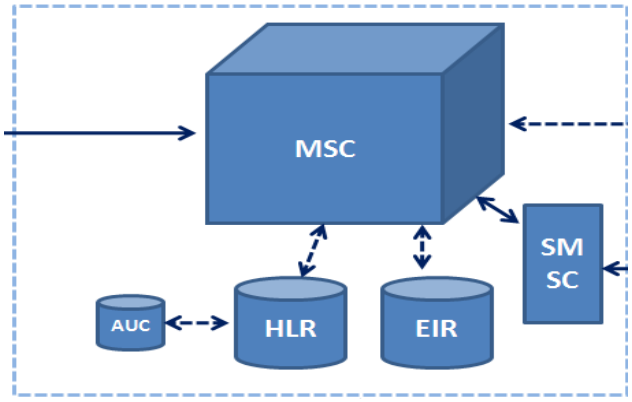


Fig 2.11MSC

2.13.2 Home Location Register (HLR):

Home location register is part of NSS of GSM cellular network. HLR interconnection between the MSC. When a user stays maximum under the same network or in the same exchange it can call home network. HLR have all the information of the user or home device in the database. Home location register have user device location, call information, call routing information. If the user changes the device HLR update the information on system. HLR also contain IMEI number.

2.13.3 Visitor Location Register (VLR):

When the user far away from the home network and going to stay on the other network for short time its call visitor location register. When user in the VLR HLR transfer all information of the user in VLR. Than VLR take care from the user. It's an impotent part of NSS system on GSM. VLR Interconnection with MSC.

2.13.4 Equipment Identity Register (EIR):

When same user device tries to inter the network have to verify on EIR. EIR entity the user device information. Make decision about whether that device allowed for the network or not. Every cell phone has international mobile equipment identity. By the IMEI number can know about user device location if the user change the SIM also can trace the cell phone. EIR block the unregister mobile. Bangladesh don't have EIR number. EIR connected with MSC.

2.13.5 Authentication Centre (AuC):

The AuC is a database, that contains the user SIM secret key. It's so protected database. It is used for ciphering on the radio channel and authentication.

2.13.6 Gateway Mobile Switching Centre (GMSC):

The GMSC is the point to which a ME ending call is at first steered, with no information of the MS's area. The GMSC is in this manner responsible for getting the MSRN (Mobile Station Roaming Number) from the HLR dependent on the MSISDN (Mobile Station ISDN number, the "index number" of a MS) and directing the call to the right visited MSC. The "MSC" some

portion of the term GMSC is deluding, since the passage task does not require any connecting to a MSC.

2.13.7 SMS Gateway (SMS-G):

The SMS-G or SMS portal is the term that is utilized to altogether depict the two Short Message Services Gateways characterized in the GSM benchmarks. The two portals handle messages coordinated in various ways. The SMS-GMSC (Short Message Service Gateway Mobile Switching Center) is for short messages being sent to a ME. The SMS-IWMSC (Short Message Service Inter-Working Mobile Switching Center) is utilized for short messages started with a portable on that arrange. The SMS-GMSC job is like that of the GMSC, though the SMS-IWMSC gives a settled passage to the Short Message Service Center.

2.14 Operation and Support Subsystem (OSS)

The operation support subsystem provided operational support hole GSM cellular system network. That do monitor and control parts in hole GSM system. Also maintains the traffic of the BSS. It must be noticed that as the quantity of BS increments with the scaling of the supporter populace a portion of the upkeep errands are exchanged to the BTS Its interconnection between BSC and NSS. Minimums the system cost.

2.15 GSM network interfaces.

Various type of interface is given blow.

- ***Um interface*** To communication or concoction between user device and base transceiver station have use that interface which Um interface. that interface connate the user with the network. Also used ISDN LAPD for signaling.
- ***Abis interface*** To communicate or connate between BSC and BTS use the Abis interface. Control radio frequency which assigned for BTS and radio equipment.
- ***A interface*** To maintain good communication between the BSS and the MSC have to use protocol or interface in that case can use A interface. Carries information use that interface

with enable channels. BSS serviced the mobile equipment to timeslots and like to be allocated channel.

- ***B interface*** To maintain communication between the MSC and the VLR have use interface or the protocol which is B interface. This interface also known as the MAP/B protocol. The MSC need access from data regarding a MS located in its area to use that B interface.
- ***C interface*** To maintain communication between GMSC or HLR and SMS-G have to user that interface which is C interface. When same user make call from out side of the network like LAN or another area have to pass the gateway to do that required the routing information to make successful call. This interface also known as MAP/C protocol.
- ***.D interface*** To maintain communication between VLR and HLR have to use that interface which D interface. That also known as the MAP/D protocol. Exchange the data uses that interface to the management and to the location of the ME.
- ***E interface*** To communicate with another network MSC or communication between 2 MSC have use that interface which E interface also known as the MAP/E interface.
- ***F interface*** To maintain communication between EIR and MSC have to be use the F interface. Also known as the interface is MAP/F protocol. The correspondences along this interface are utilized to affirm the status of the IMEI of the ME accessing the system.
- ***G interface*** When one exchange VLR try to communicate with another exchange VLR have to use G interface. Using that interface VLR transfer information of user to another VLR during Location update. Also known as the MAP/G protocol.
- ***H interface*** To send short message use H interface. To communication between SMS-G and MSC use that interface and is also known as MAP/H
- ***I interface*** To communication between MSC and ME use that interface which is I interface. Also known as MAP/I protocol.

2.16 GSM security

GSM was planned to be a protected remote framework. It has considered the client verification utilizing a pre-shared key and test reaction, and over-the-air encryption. Nonetheless, GSM is powerless against various sorts of assault, every one of them went for an alternate piece of the system.

The improvement of UMTS presented a discretionary Universal Subscriber Identity Module (USIM), that utilizes a more drawn out verification key to give more noteworthy security, and commonly validating the system and the client, while GSM just verifies the client to the system (and not the other way around). The security display in this way offers secrecy and verification, yet constrained approval abilities, and no non-revocation.

GSM utilizes a few cryptographic calculations for security. The A5/1, A5/2, and A5/3 stream figures are utilized for guaranteeing over-the-air voice protection. A5/1 was produced first and is a more grounded calculation utilized inside Europe and the United States; A5/2 is more fragile and utilized in different nations. Genuine shortcomings have been found in the two calculations: it is conceivable to break A5/2 progressively with a ciphertext-just assault, and in January 2007, The Hacker's Choice began the A5/1 splitting task with plans to utilize FPGAs that permit A5/1 to be broken with a rainbow table assault. The framework bolsters various calculations so administrators may supplant that figure with a more grounded one. Since 2000 unique endeavors have been made so as to split the A5 encryption calculations. Both A5/1 and A5/2 calculations have been broken, and their cryptanalysis has been uncovered in the writing. For instance, Karsten Nohl [de] built up various rainbow tables (static qualities which diminish the time expected to do an assault) and have discovered new hotspots for He said that it is conceivable to manufacture "a full GSM interceptor...from open-source segments" however that they had not done as such in light of lawful concerns. Nohl asserted that he had the ability to catch voice and content discussions by mimicking another client to tune in to phone message, make calls, or send instant messages utilizing a seven-year-old Motorola cellphone and decoding programming accessible for nothing on the web. GSM utilizes General Packet Radio Service (GPRS) for information transmissions like perusing the web. The most generally sent GPRS figures were openly broken in 2011. The scientists uncovered blemishes in the normally utilized GEA/1 and

GEA/2 figures and distributed the open-source "gprsdecode" programming for sniffing GPRS systems. They likewise noticed that a few transporters don't scramble the information (i.e., utilizing GEA/0) so as to recognize the utilization of traffic or conventions they don't care for (e.g., Skype), leaving clients unprotected. GEA/3 appears to remain generally difficult to break and is said to be being used on some progressively present-day systems. Whenever utilized with USIM to avert associations with phony base stations and downsize assaults, clients will be secured in the medium term, however movement to 128-piece GEA/4 is still suggested.

2.17 GSM frame structure

The most impotent part is GSM architecture is GSM frame. Its have 8 time slots, each of them used for different users within the TDMA system in millisecond. That minimum the number of slots. In this system mobile equipment can’t transmit and receive at the same time.

Burst period is the fundamental unit. It’s existed for approximately 57 milliseconds. Those type of 8 burst period build together in a TDMA frame or time slots which exist for approximately 4.61 millisecond. For one physical channel of each TDMA frame one burst channel is assigned.

Traffic and control two types of channel assigned for BTS. This channel basic architecture divided into 2 different types of frame one is assigned for control on the frequency and another one is assigned for traffic carrier frequency.

Chaptere 3

Types of cellular network technologies

3.1 Definition

With the time cellular network types change for good. It came with generation. Each of generation came with new technique, New schemas, improve uplink and downlink speed. In this chapter we talk about each of mobile telecommunication generation. Which is 1G,2G,3G,4G as well as 5G.

3.2 First generation

In early 1982 world was introducing with first wireless cellular network which finally done in 1990 its known as 1G. its only offer voice services no data services in this network. Allows to calls in one country. It's based on full analog system. This named the technology Advanced mobile phone system (AMPS). Consume high power to operated and poor handoff system. User device come with big size. Channel capacity only 30 kHz and frequency band can use for this system only 824-894 MHz Use FDMA and frequency modulation (FM)

The Push to Talk (PTT). It has low capacity, unreliable handoff, poor voice links, and no security at all since voice calls were played back in radio towers, making these calls susceptible to unwanted eavesdropping by third parties.

3.3 2G second-generation

After the few years' time of 1G Finland By Radiolinja launched 1st commercial network GSM which also call 2G 2nd generation cellular network in 1991. It's a big innovation in cellular network. It provides voice and data service.2G first introduce data transform system in the network.in 2nd generation network can send text messages. Also add new service like MMS, picture messages. Provide good quality voice services. Data transform speed in 26kbps to 64

kbps. Run on the system in full digital way here is 1G is analog. Increases big number of capacities in the network. No video steaming service in the network.

2.3.1 2.5G (GPRS)

Few year later 2G get updated to 2.5 which also call as second and half generation cellular network. This system uses packet-switching and circuit-switching. In this way data speed become so high no extra technique needs to use. This generation also known as GPRS. It's provided 64 to144 kbps. Faster wap browsing than 2G. Possible send E-mail with this speed. Base in this generation start to build camera phone.

3.3.2 2.75G (EDGE)

In 2003 2G generation add new technique in this family which is 2.75G. Also known as EDGE cellular network. This generation speed is higher than 2.5G. Its use 8PSK encoding to increases the internet speed. In this technique can possible video steaming. 2.75G or EDGE is developed by AT&T in the United States. Also known as Enhanced GPRS.

3.4 3G third generation

The international telecommunication Union introduce third generation or 3G cellular network for mobile telecommunication. It's come form 2.5G and 2.75G GSM system. This generation internet speed is so high up to 7mbps maximum 21mbps. With this speed can do many things like online TV. Online video, online sport, video calls etc. Many new devices have been built to run with this speed on this generation network like laptop which have high configuration. Life become so easy with is generation. Also develops round this generation are communication Global Positioning System (GPS), Video Conferencing and Mobile TV. To run 3G in tower have install WMPT or UMPT transmission card in the BTS. Its full digital technique. This technique used packet-switching. Data cost is very low in this generation.

3.5 4G fourth generation

After 3G few year later 4G add in GSM technology. 4G or fourth generation is broadband in cellular network technology. Fourth generation capable of offer ITU in IMT advance. Its use UMPT transmission card in BTS to RUN. This generation internet speed so higher than other generation. This generation internet speed up to 100Mbps. Almost every country in the world run this generation. Can do with this speed are online gaming, HDTV, 3DTV, clear video conferencing. Its ca offers 1Gbps speed, high quality video streaming, multi-media news sport, High security. In carrier use frequency-division multiplexing(OFDM), code division multiple access (CDMA) and time division multiple access (TDMA). 4G have 4G advance which is LTE Long Term Evolution its have extra additional service.

3.6 Fifth Generation (5G)

8 year ago in 2010 world introduce with 5G or fifth generation on cellular network. 5G offer more coverage and provide good connectivity. 5G limited now few centuries used that technology. 5G come with WWWW wireless world wide wab. It's the most advance technique in the world in GSM cellular network. Its supported speed is Gbps almost unbelievable speed in the world on GSM cellular network. Online service become so popular in sech technique. Online tv, game all became full HD and 4K version. It came in the market in the 2020. Now it's in research mode. Its maybe 15% to 20% faster and advance than 4G GSM cellular network.

Fig 3.1 5G

Technology	1G	2G	3G	4G	5G
Start	1970-80	1990-2004	2004-2010	Now	Soon (2020)
Data bandwidth	1Kbps	64kbps	2Mbps	1Gbps	Higher than 1 Gb
Core network	PSTN	PSTN	Packet N/W	Internet	WWWW
Technology	Analog	Digital	CDMA 2000, UMTS	Wi-max, LTE	Internet
Multiplexing	FDMA	TDMA/CDMA	CDMA	CDMA	CDMA
Switching	Circuit	Circuit and packet	Packet	All packet	All packet
Primary service	Analog phone calls	Digital phone calls and massaging	Phone call massaging data	All-IP	Higher speed, Capacity, data rete in Gb
Key differentiator	Mobility	Secure, mass adoption	Better internet experience	Faster broadband internet, lower latency	Better coverage, performance and no droped calls
Weakness	Poor spectral efficiency, major security issue	Limited data rates, difficult of support demand for internet and email	Real performance fail to match type, failure of WAP for internet access	Battery uses more, required expansive hardware.	?

Table 3.1 evolution of 1G to 5G

1G to 5G big change in cellular network. Speed increase so mush 2kbps to 1Gbps. Used Packet switching over Circuit switching. Communication become so easy. Decrease the dropped call, power consumption, data cost par bit. More coverage of the network. High spectral efficiency. High security. Lower latency.

Chapter 4

New Base Transceiver Station (BTS) installation For 4G

4.1 Introduction

The base transceiver station (BTS) is a part of BSS in the GSM cellular system. BTS transmit signal to cover the fix area. BTS receive the Call from the MS unit. Transmit the call in the MSC in the GSM architecture. Use Um interface to concoction between mobile station unit and base transceiver station. BTS run on commercial power, electrical generator, Soler energy and battery. BTS have 4 type Pole site, green field, roof top, guy mast towers. In BTS install communication device to communicate on user to another user. A GSM BTS have GSM antenna, microwave antenna, different type of transmission card like UMPT, WMPT, GMPT, UBBP, UBRI etc. Use rectifier to convert ac to dc power. Without BTS cellular system is useless.

4.2 Why

New Base Transceiver Station (BTS) install for cover that area where no network is existing before. Increase the network coverage. To connect more user or MS to the network. In the Bangladesh have 5 mobile network operators. Each of them tries to take more coverage by their network with best deal and best cellular technologies like 3G,4G. That's why have installed more base transceiver station (BTS) with 4G support equipment.

4.3 Indoor Equipment of BTS

To install new base transceiver station, we have ensured that indoor equipment on the BTS site.

List of equipment:

- BTS Cabinet
- BBU (Baseband Unit)
- MRFU/DRFU/GRFU
- Rectifier
- DCDU
- Automatic Voltage Regulator (AVR)

- Battery Rack
- Generator
- Circuit Breaker
- Fuse
- Grounding Bar

4.3.1 BTS Cabinet

A BTS cabinet is a cabinet where main is equipment install like BBU, transmission card, DCDU.

Fig 4.1 BTS Cabinet

4.3.2 BBU-Base Band Unit

Base band unit is very important part of the BTS. It's a main processing unit of BTS. Can also say mother of the BTS. Without Base band unit BTS is impassable. Main function of BBU is processes the signal un-modulated frequency before modulated. It's can convert analog signal to digital signal or digital to analog signal using DSP (digital signal processor). In BBU install transmission card, Power card for 2G to 4G. Have cooling FAN.

Fig 4.2 Base band unit

Functions of BBU:

1) BBU have CPRI port for CPRI cable (optical fiber) this cable connect BBU and RRU for processes downlink and uplink baseband signal.

2) Gives S1 ports to correspondence between an E-baseUTRAN NodeB (eNodeB) and an MME/S-GW, and X2 ports for correspondence between eNodeBs.

3) Gives clock ports to clock synchronization, alert checking ports for condition observing, and a Universal Serial Bus (USB) port for dispatching utilizing a USB streak drive.

4) Deals with the eNodeB through operation (OM) and signaling message handling. Maintaining part.

can show in the figure BBU basically have Power, Transmission card and FAN. Brief description of those element is given below:

FAN: In BBU FAN is use for to decrease the heat. Depend on the temperature FAN wing is rotated. If the temperature is high FAN rotation is fast. If the temperature is low fan rotation is low. In winter no need for fan. In summer fan become use full.

LBBP/UBBP: In the BTS on the BBU found UBBP Universal Base Band Processing Unit or LBBP LTE Base Band Processing Unit. LBBP LTE Base Band Processing Unit used in BBU version 3900 it's had 3 version LBBPa, LBBPb, and LBBPc. Universal Base Band Processing

Unit support in BBU 3910 basic different is Universal Base Band Processing Unit use for 2G and 3G. It's had 2 version UBBP2 and UBBP3. LTE Base Band Processing Unit for 4Gand LTE.

Fig 4.3 UBBP

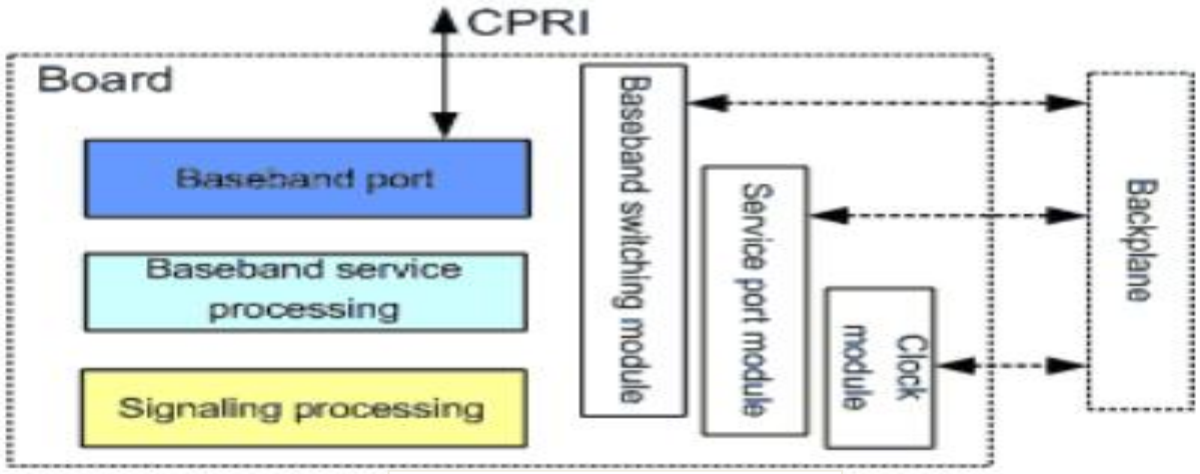
Board	UBBPd1 UBBPd2	UBBPd3	UBBPd4	UBBPd5	UBBPd6	UBBPd9	UBBPda
Applicable Mode	GSM UMTS GU co-BBP	GSM UMTS LTE FDD GU co-BBP GL co-BBP	GSM UMTS LTE FDD LTE TDD GU co-BBP GL co-BBP	GSM UMTS LTE FDD GU co-BBP GL co-BBP	GSM UMTS LTE FDD LTE TDD GU co-BBP GL co-BBP UL co-BBP GUL co-BBP	LTE TDD	LTE FDD

Table 4.1 Board & applicable

Board	**Number of Cells**	**Cell Bandwidth (MHz)**	**Antenna Configuration**
UBBPd3	3	1.4/3/5/10/15/20	3x20 MHz 1T1R
UBBPd4	3	1.4/3/5/10/15/20	3x20 MHz 1T1R 3x20 MHz 1T2R 3x20 MHz 2T2R 3x20 MHz 2T4R 3x20 MHz 4T4R
UBBPd5	6	1.4/3/5/10/15/20	6x20 MHz 1T1R 6x20 MHz 1T2R 6x20 MHz 2T2R 3x20 MHz 4T4R
UBBPd6	6	1.4/3/5/10/15/20	6x20 MHz 1T1R

			6x20 MHz 1T2R 6x20 MHz 2T2R 6x20 MHz 2T4R 6x20 MHz 4T4R
UBBPda	6	1.4/3/5/10/15/20	6x10 MHz 2T4R 6x20 MHz 1T1R 6x20 MHz 1T2R 6x20 MHz 2T2R

Table 4.2 Cell specifications of a UBBP



Working principle of a UBBP

UMPT: In the BTS on the BBU found UMPT Universal Main processing and transmission unit. Its functions are:

1) UMPT dealing with signal processing, monitoring performance, management of equipment and active switchover.
2) Gives clock reference, transmission ports, and the support interface associating with the OMC. The OMC can be the LMT or M2000 customer.
3) It's a universal transmitter transmit all kind of network like 2G, 3G, 4G.

Fig 4.4 UMPT

UPEU: In BTS on the BBU found UPEU Universal Power and Environment interface unit card. It's a basically power card. Main function is:

1) Its convert input power at -48v to protect the BTS equipment. Minus power don't harm the equipment. Its protect from thundering
2) It takes EMUB call data through RS485 sequential correspondence and changes over.

Fig 4.5 UPEU

WMPT: In the BTS on BBU found at slots3 WMPT Main Processes and Transmission unit card. This card only use for 3G GSM cellular network. It's transmit and processes the signal. This card also provide control and management unit for 3G. It's have USB port to software upgrade and data configuration. Card consist of ATM and IP protocols and Provides the reference clock. Offer monitoring performance, configuration management, equipment management, signaling processing.

Fig 4.6 WMPT

GMPT: In the BTS on BBU found GMPT card. It's a **2G** Transmission card. Its install in BBU 5th card slots. Offer monitoring performance for 2G. configuration management for 2G. equipment management for 2G, signaling processing for 2G.

Fig 4.7 GMPT Card

BBU comprises of GPS sensors or gadget which track the BBU introduced area and if BBU is stolen or burglary the GPS arrange is followed and send back to telecom administrator control room.

There are numerous BBU models made by different telecom administrators. The best 5 telecom gear producer are Ericsson, Alcatel-Lucent, Huawei Technologies, Cisco Systems and ZTE Corporation. These sellers have their own kind sort BBU demonstrate however the fundamental learning is same. The distinctive is that of their capacity proficiency and preparing and working pace.

4.3.3 MRFU

The MRFU 900B can be used in an indoor cabinet or a protective outdoor cabinet. RF signal can be modulate help of MRFU. RF signal can be demodulate with MFRU. Combine two RF signal and can divide. It's had Software Defined Radio (SDR) technology that processes baseband and RF signal. Install in BTS cabinet with side of BBU.

Fig 4.8 MRFU

Port	Connector	Quantity	Function
RF port	DIN	2	Connects to an antenna
Interconnection port for receiving RF signals	QMA female	2	Connects to the another RF module
Common public radio interface (CPRI) port	SFP female	2	Connects to the baseband unit
Power supply socket	3V3	1	Receives -48 V DC power
MON port	RJ45	1	Port for monitoring and maintenance

Table 4.3 Physical ports on the

Type	Frequency Band (MHz)	RX Frequency Band (MHz)	TX Frequency Band (MHz)	IBW (MHz)
MRFU 900B	900 PGSM	890–915	935–960	25
900 EGSM	880–915	925–960		
1800	1710–1785	1805–1880	35	

Table 4.4MRFU 900B frequency

Mode	Frequency Band (MHz)	1-Way Receiver Sensitivity (dBm)	2-Way Receiver Sensitivity (dBm)	4-Way Receiver Sensitivity (dBm)
GSM	900 PGSM	–113.3	–116.1	–118.8 (theoretical value)
900 EGSM	–113.3	–116.1	–118.8 (theoretical value)	
1800	–113.8	–116.6	–119.3 (theoretical value)	
UMTS	900 PGSM	–125.3	–128.1	–130.8
900 EGSM	–125.3	–128.1	–130.8	
LTE	900 PGSM	–106.3	–109.1	–111.8
900 EGSM	–106.3	–109.1	–111.8	
1800	–106.5	–109.3	–112.0	

Table 4.5 MRFU 900B receiver sensitivity

Mode	Configuration	Output Power per Carrier (W)	Typical Power Consumption (W)	Maximum Power Consumption (W)
GSM+ LTE	GSM: S2/2/2 + LTE: 3x10 MHz, 1 carrier	GSM: 20 LTE: 20	920	1095
GSM: S3/3/3 + LTE: 3x10 MHz, 1 carrier	GSM: 20 LTE: 20	1010 BPd	1285	
LTE	3 x 10 MHz	2 x 60	1230	1355
LTE	3x10MHz	2x60	1185	

Power Consumption BTS

4.3.4 Rectifier

In the base transceiver station need rectifier to convert AC to DC current. In the BTS have backup battery which store the DC current as AC when commercial power is gone battery current which is AC go to the rectifier than rectifier convert the AC to DC That DC current run the all base transceiver station equipment. Rectifier is like BTS device filter.

Fig4.9 Rectifier

4.3.5 Automatic Voltage Regulator (AVR)

The Automatic Voltage Regulator or AVR responds to sudden difference in Generator stack by giving the comparing excitation voltage, under the new load conditions. The reaction of a voltage which controls the Generator's terminal voltage is along these lines, a component of reactions of the voltage controller, the exciter, and the primary Generator flux. The reaction time of the AVR is the time required for the controller to make a move following the voltage change.

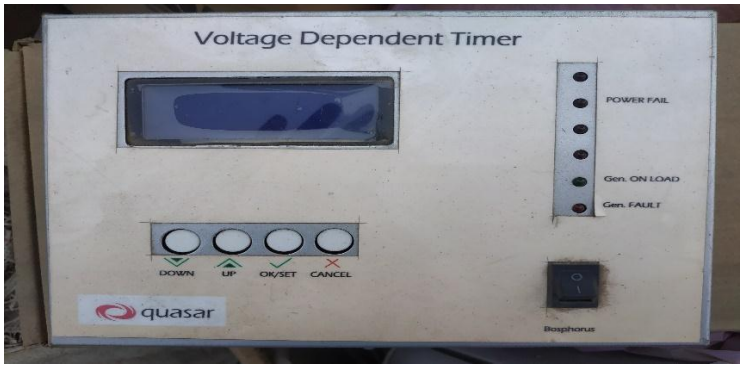


Fig 4.10 AVR

4.3.6 Battery Rack

In the BTS all battery organics in the battery rack**.**

Fig 4.11 Battery rack

4.3.6 Generator

To run BTS device when commercial device is gone need external power sources like generator. Generator on BTS convert mechanical energy into electrical energy to run BTS device to maintain non-stop communication Most of the place generator does not use generator because it costly and power loss to much.

Fig 4.12 Generator

4.3.7 Circuit breaker

To protects base transceiver station electrical circuit or electrical device to high voltage, low voltage short circuit and from overload use circuit breaker. Circuit is a electrical switch designed to operated automatically. If any fault occurred in the BTS circuit or system overloaded it's gets off and stop the current when problem is gets solve BTS system run automatically.

4.3.8 Fuse

Fuse is a method or engineering to protects BTS electrical device. In circuit breaker use that fuse. Fuse stop current over flow and stop voltage over flow or short circuit. Fuse can be metal wire or advance switch.in BTS use switch type fuse.

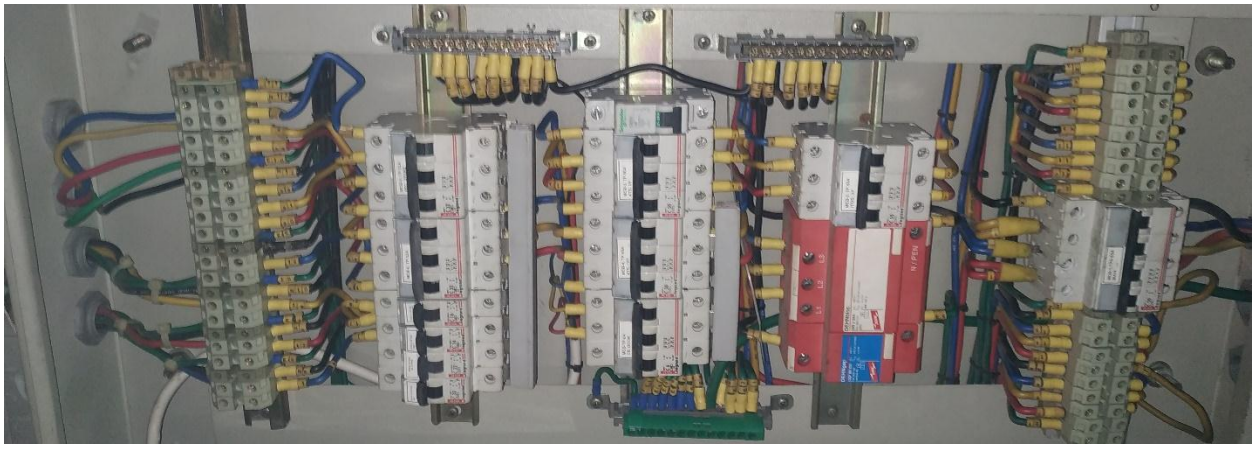


Fig 4.13 Fuse

4.3.9 Ground Bars

In BTS ground bars installed for protect GSM antenna, MW antenna, RRU other indoor and outdoor equipment from thunder lighting or electrical shocks of high voltage. Basically, Grounding bars made of copper and variety of thickness and lengths.

Fig 4.14 ground bars

4.3.10 Direct Current Distribution Unit

DC distribution unit or direct current distribution unit install in base transceiver station to power BTS device like RRU, BBU, different type of alarm, EMUB. DCDU current come from the rectifier. For DCDU BTS cabinet become more organizes. Huawei DCDU-12B have 10 separate output for each device and two input from rectifier. Its input come from rectifier so input power is -48v. Output is also same provided -48v. It comes with light weight and capable of work in the low temperature.

Fig 4.14 DCDU

4.4 Transmission Rack

In base transceiver station Transmission rack install to organize transmission device. It's an indoor unit like telephone exchanges. This rack build on ETSI standards have the RU or SU device rails. ETSI follow 19" or 21" rack size.

Features

- Have MW antenna transmission unit
- BUS BAR GND
- Have positive fuse and
- The negative fuse.
- Various latches to encourage establishment
- Variety of extras

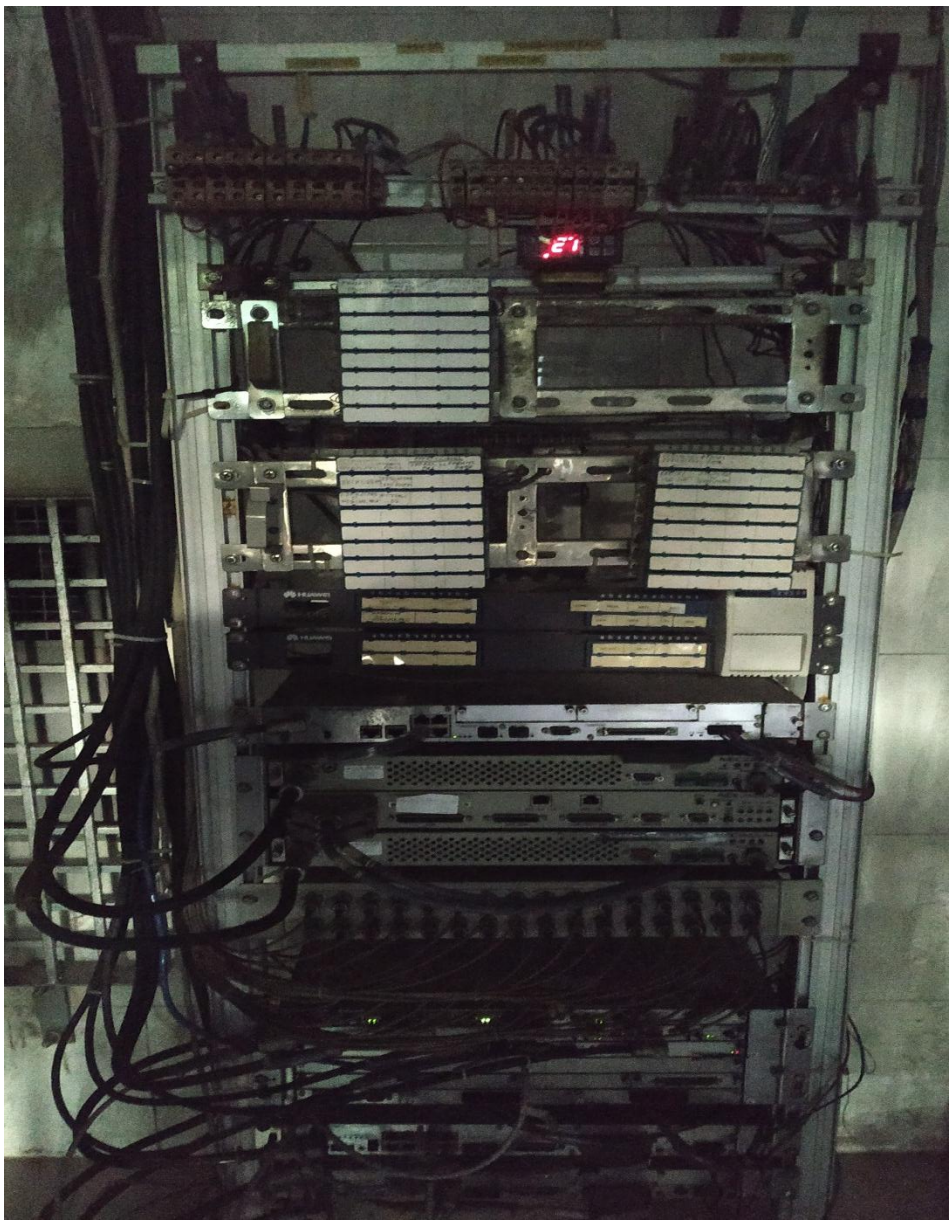


Fig 4.15 Transmission Rack

4.5 Other indoor unit

- Smoke Detectors
- Door Alarm
- Water Sensor
- Fire alarm
- Temperature Sensor
- Cascade Cable
- Air-Condition
- Ladder
- Rox-tec / Feeder Hole

4.5.1 Smoke Detectors and Fire alarm

Smoke sensor install is the base transceiver station to avoid any fire incident. Its use to protect de base transceiver station device from the fire. If any smoke is detected by the sensor its alert the service operators of that base transceiver station.

Fig 4.16 Smoke Detectors

4.5.2 Door Alarm

Door alarm install in the BTS door if any unauthorize parson try to brake-in alarm goes to the server to operate. Take an action against that.

Fig 4.18 Door alarm

4.5.3 Water Sensor

A water sensor is installs in the base transceiver station to detect the water level of there. It's protected base transceiver station device from water or float. If water sensor senses any water bubble alert the operator to take action agented it.

Fig 4.19 Water Sensor

4.5.4 Temperature Sensor and Air-Condition

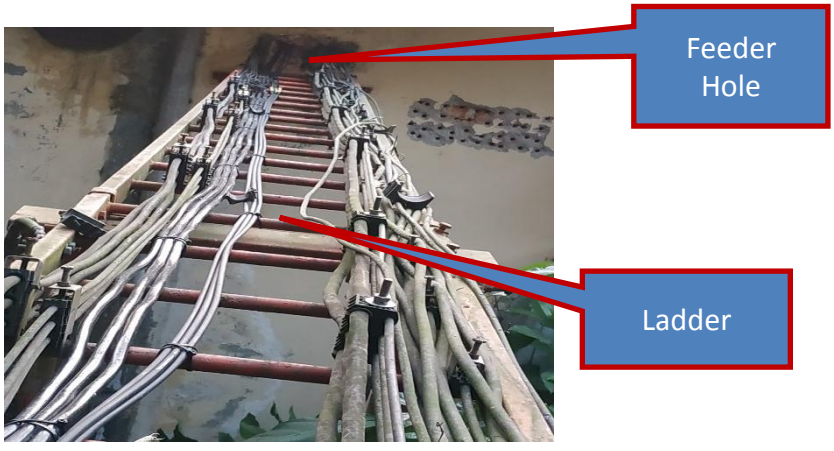
Temperature sensor install in BTS to measure the temperature of BTS room. If the room temperature increase or decrease refer to ideal temperature than take action against the Temperature Sensor 1temperature. If temperature could be at summer so build air condition system or ventilator.

Fig 4.20 Air con

Temperature Sensor

4.5.5 Ladder and Feeder Hole

In the BTS ladder use to hold the feeder cable, cascade cable, optical fiber, CPRI cable etc. Feeder hole is the hole use to connect feeder cable in BTS room in MRFU.



4.6 Outdoor Equipment

Outdoor equipment installs in the outside BTS tower Like:

- RRU
- GSM Antenna
- Microwave Antenna
- Feeder Cable (½ super flex 10m,½ Flex 28m,7/8 Flex 78m,15/8 flex 96m)
- CPRI Cable
- Connector
- Thundering Arrestor
- Grounding Bar

4.6.1 RRU

RRU is install in the outdoor unit of the base transceiver station to interaction between user and operator and distributed integrated frequency unit. It's full from radio remote unit is Radio Remote Unit. For 4G have to use RRU 1800. Radio Remote Unit call take capacity mush higher then MRFU almost twice. RRU take call through GSM antenna which is connected with RRU by ½ Feeder cable also known as short jumper. The EM received signal can be process and control by RRU. Then RRU connected with BBU by the CPRI cable (optical fiber).

Fig 4. 21 RRU

4.6.2 GSM Antenna

Most important equipment of outdoor BTS is GSM antenna it's come with different types of band of frequency like 850 and 900 for 2G,1800 for 4G and 2100 for 3G. It's an omnidirectional antenna. Cover fix area. GSM antenna connect with RRU by short jumper ½ feeder flex cable or with MRFU by 7/8 or 15/8 feeder cable. It's come with single band, dual band and tri band for 4G batter use tri band GSM antenna. Without GSM antenna can't think about GSM architecture. 2G to 4G use GSM antenna

Fig4.22 GSM Antenna

4.6.3 Microwave Antenna

After install Base transceiver station have link with to connect others Base transceiver station to inter the network. That can be done with two way one is microwave or optical fiber link. To Microwave link have install MW antenna in outdoor unit in the Base transceiver station. It's have been short distance and no objective should be allowed between two MW antenna. Kind of line of side communication.

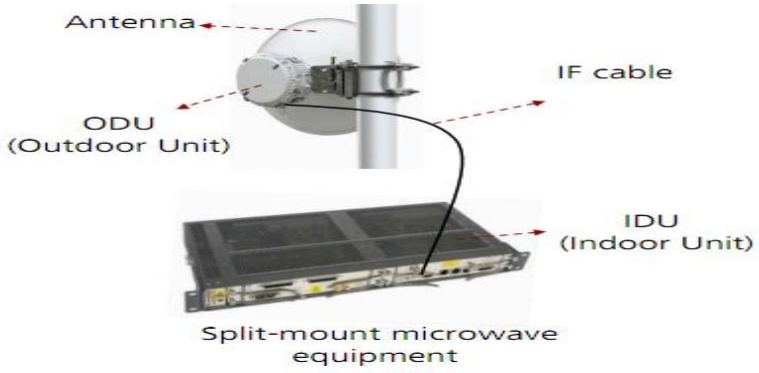


Fig 4.23 MW antenna

MW have 2 unit

- Indoor: Indoor unit do MUX or DEMUX process of IF signal
- Outdoor: Outdoor unit power the IF signal

Indoor unit and outdoor unit are interconnected by IF cable.

4.6.4 Feeder Cable

Feeder cable use BTS to connection between GSM antenna to MRFU and RRU. It's had excellent flexibility. Its camas with this configuration:

- 1/2 super flex use distant in 10m high basically use into connection between RRU and GSM antenna.
- 1/2 Flex use in distant 28m high also use into connection between RRU and GSM antenna.
- 7/8 Flex use in distant 78m high use into connection between MRFU and GSM antenna.
- 15/8 Flex use in distant 96m high use into connection between MRFU and GSM antenna.

4.6.5 CPRI Cable

The Common Public Radio Interface (CPRI) is an industry cooperation aimed at defining a publicly available specification for the key internal interface of radio base stations between the Radio Equipment Control (REC) and the Radio Equipment (RE). Use to connection between RRU to BBU.

4.6.6 Connector

There is two type of connector use in BTS technologies in connecting or feeder cable which is:

- L type
- I type

Fig4.24connector

4.6.7 Thundering Arrestor

A lightning arrester (alternative spelling lightning arrestor) (also called lightning diverter) is a device used on electric power systems and telecommunication systems to protect the insulation and conductors of the system from the damaging effects of lightning.

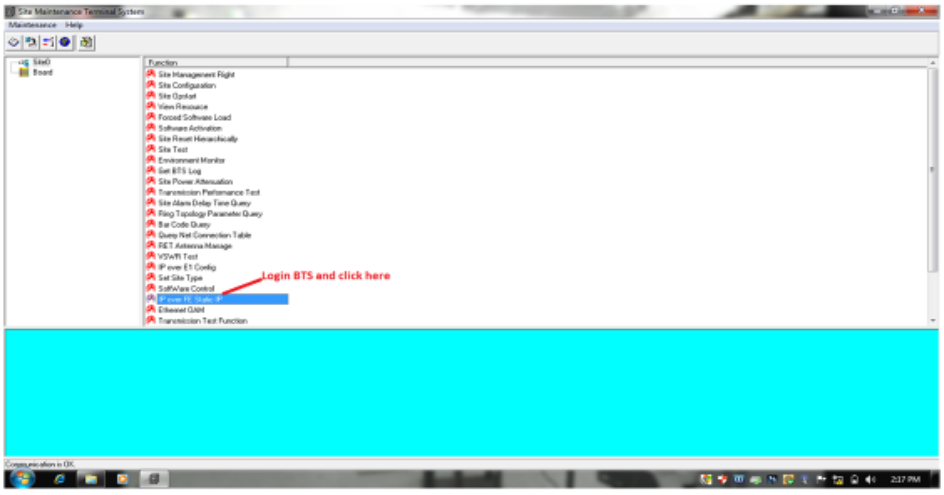
4.7 BTS Commissioning

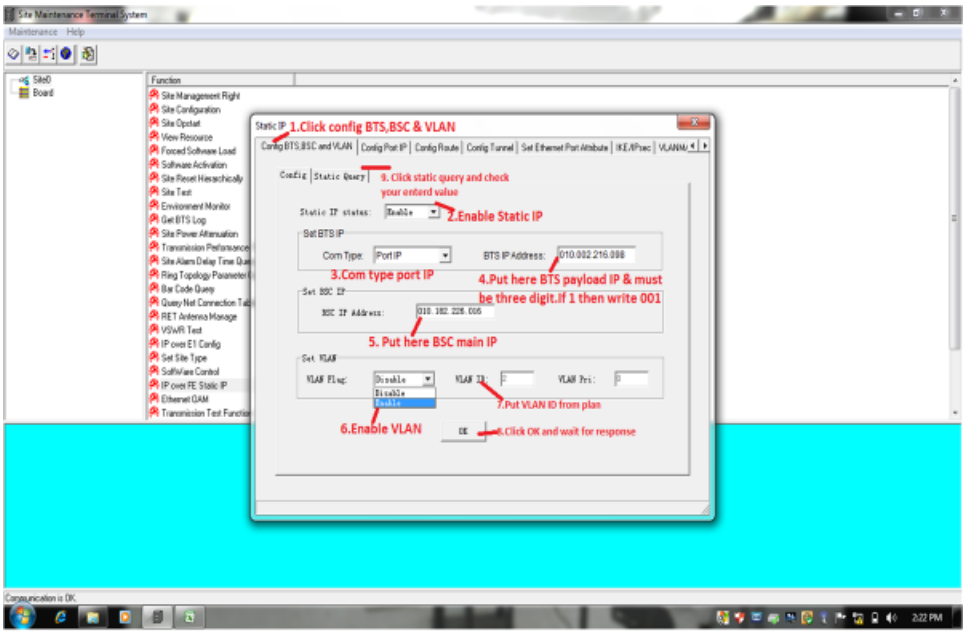
After the install to all equipment successfully now have to do BTS commissioning part to run BTS successful.

- It is most important part of BTS installation
- In this part we have to upload the script in the BTS.
- Then service operator active that BTS by server.

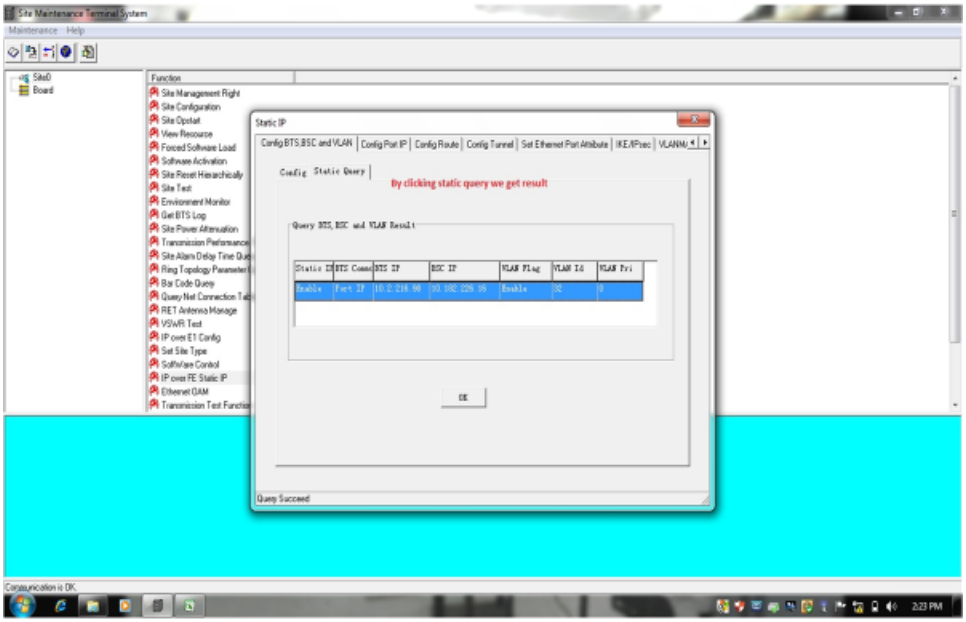
4.7.1 BTS Commissioning procedure:

BTS commissioning procedure through static IP

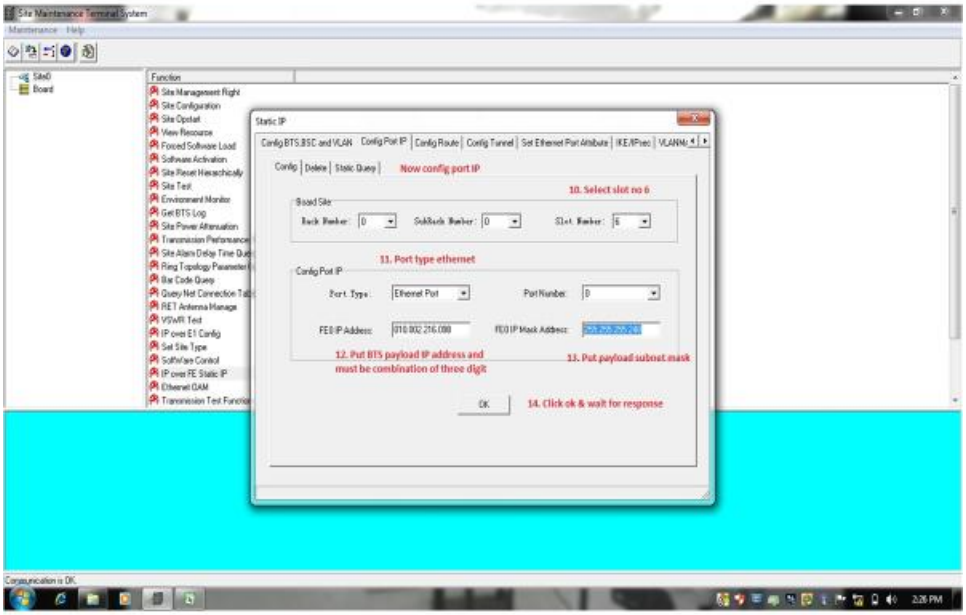




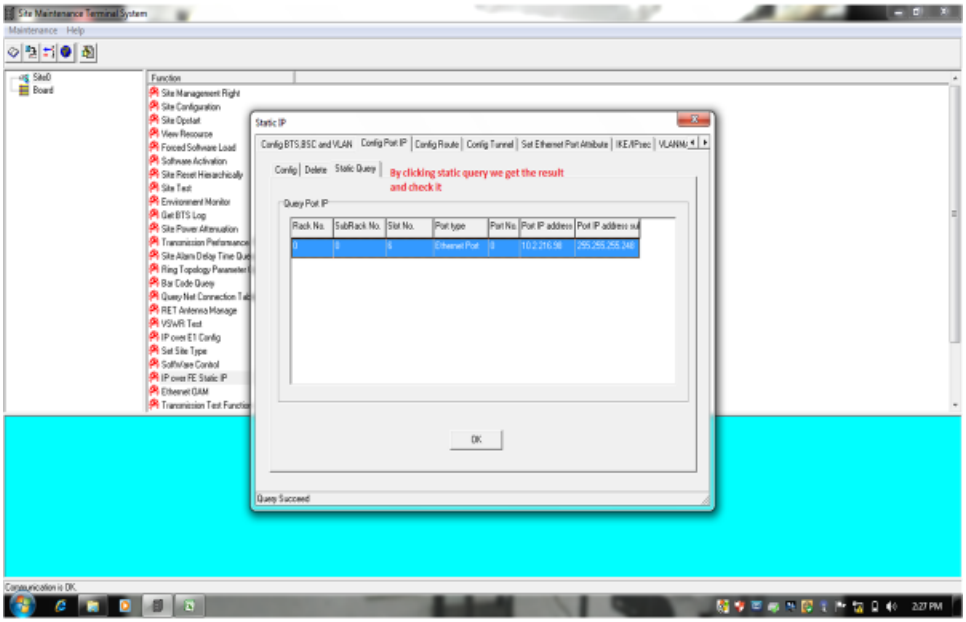
Config BTS,BSC and VLAN



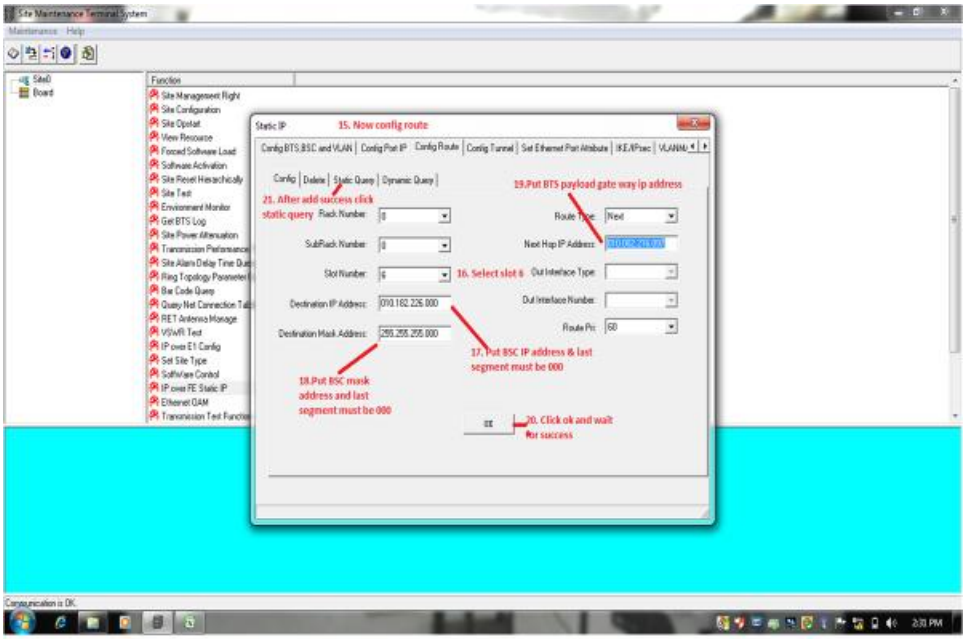
Summery of BTS,BSC and VLAN after configuration



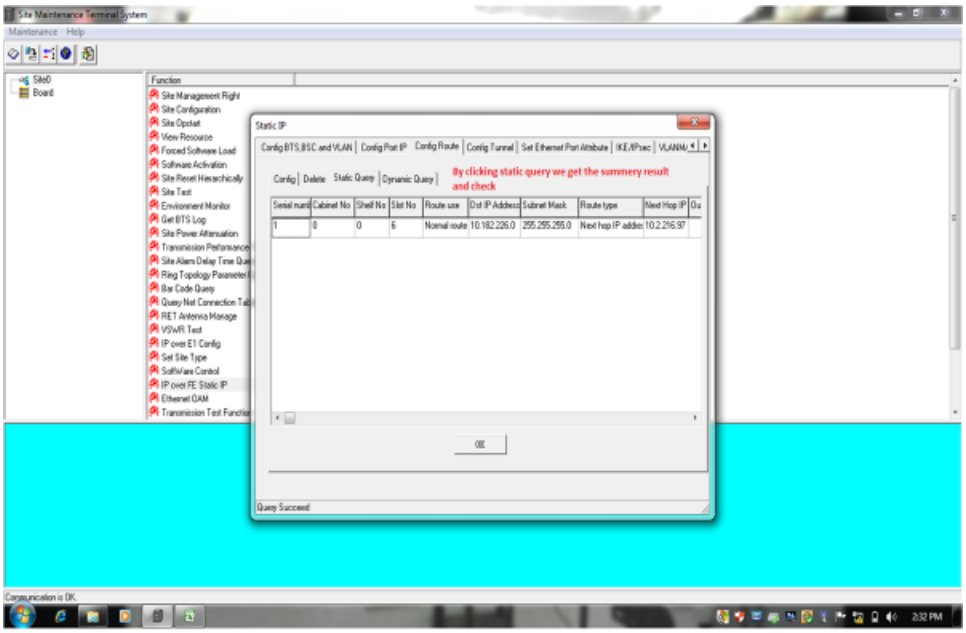
Port IP configuration



Port IP configuration summery



Route configuration



Summery after route configuration

Chapter5

Conclusion

5.1 Conclusion

Working in Starlink Engineering Limited big opportunity me . It's a first experience of corporate life. Every day is new experience. Have to go new site every day in full new places. Work we doing in the company new BTS site, cell splitting etc. Every day known about new kind of BTS device like GSM antenna, RRU, microwave antenna, BBU. MRFU, rectifier etc.

How they function. How to install dose device in BTS site. How to Commissioning BTS tower.

5.2 Limitation of the work

- If the BTS tower in the roof top have get permission from building owner some time we get problem with permission matter.
- Same time deal with local people on the site.
- I don't allow to deal with the commissioning part

REFERENCE

1. https://en.wikipedia.org/wiki/Cellular_network [Accessed Time: 9:39 PM 12-Dec-18]
2. http://telecombase.blogspot.com/2016/07/bbu-baseband-unit-in-telecom.html[Accessed Time: 9:40 PM 12-Dec-18]
3. https://edoc.site/rru3908-pdf-free.html[Accessed Time: 9:45 PM 12-Dec-18]
4. http://telecombase.blogspot.com/2016/09/remote-radio-unit-rru-functions-details.html [Accessed Time: 9:40 PM 12-Dec-18]
5. https://www.electronics-notes.com/articles/connectivity/2g-gsm/network-interfaces.php [Accessed Time: 9:50 PM 12-Dec-18]
6. https://en.wikipedia.org/wiki/2G [Accessed Time: 9:53 PM 12-Dec-18]
7. https://pdfs.semanticscholar.org/4dfd/40cc3a386573ee861c5329ab4c6711210819.pdf[Accessed Time: 9:56PM 12-Dec-18]
8. http://www.gyantemple.com/full.php?ID=191 [Accessed Time: 9:59 PM 12-Dec-18]
9. http://www.cathayradio.org/news/newslet_July2015.pdf [Accessed Time: 10:03 PM 12-Dec 18]
10. https://www.mobilemark.com/antenna-solutions/gsm-antennas/gsm-antenna-esign/[Accessed Time: 10:10 PM 12-Dec-18]
11. http://docplayer.net/2385900-Cellular-network-organization.html [Accessed Time: 10:25 PM 12-Dec-18)
12. http://www.honorcup.ru/upload/iblock/164/2.pdf[Accessed Time: 10:50 PM 12-Dec-18]
13. http://beprojectreport.com/download/E3-AUTOMATIC-WATER-LEVEL-MONITORING-SYSTEM-USING-GSMTECHNOLOGY.pdf [Accessed Time: 11:01 PM 12-Dec-18]
14. http://telecombase.blogspot.com/2015/12/dcdu-dc-distribution-unit-of-huawei.html [Accessed Time: 11:25PM 12-Dec-18]
15. https://www.scribd.com/document/230045961/Telecom-concepts [Accessed Time: 11:50 PM 12-Dec-18]
16. https://www.slideshare.net/naveenjakhar12/gsm-base-transceiver-station [Accessed Time: 12:12 PM 12-Dec-18]
17. http://xa.yimg.com/kq/groups/23369832/1949447783/name/project+book2.docx[Accessed Time: 12:25 PM 12-Dec-18]
18. http://tlclab.unipv.it/downloads/Sistemi%20di%20Trasmissione%20Radio/20080416/06_Sistemi_radiomobili_cellulari.p [Accessed Time: 01:25 PM 12-Dec-18]
19. https://pt.scribd.com/document/240243228/Huawei-Bts-3900-Training[Accessed Time: 1:50 PM 13-Dec-18]
20. http://docslide.us/documents/3900-series-base-station-technical-description-06pdf-en.html [Accessed Time: 2:03 PM 13-Dec-18]
21. http://dlibrary.univ-boumerdes.dz:8080/bitstream/123456789/3278/1/MC112015pdf. [Accessed Time: 2:50 PM 13-Dec-18]
22. http://www.rroij.com/open-access/prepaid-power-billing-using-adaptive-meter.php?aid=44235 [Accessed Time: 3:50 PM 13-Dec-18]

23. https://repository.unikom.ac.id/47216/1/Bab%202%20Cellular%20System.pdf[Accessed Time: 4:50 PM 13-Dec-18]
24. .http://www.basicelectricalengineering.com/ [Accessed Time: 5:50 PM 13-Dec-18]
25. https://searchmobilecomputing.techtarget.com/definition/4G [Accessed Time: 6:50 PM 13-Dec-18]
26. http://etheses.saurashtrauniversity.edu/341/1/vandra_kh_thesis_computer%20Engineering1.pdf [Accessed Time: 7:57 PM 13-Dec-18]
27. https://www.coursehero.com/file/19777743/GSMHuwaie/[Accessed Time: 8:54 PM 13-Dec-18]
28. http://pet.ece.iisc.ernet.in/downloads/uc2008/PDFs/Day14.pdf [Accessed Time: 8:00 AM 15-Dec-18]
29. https://en.m.wikipedia.org/wiki/Smoke_detector[Accessed Time: 8:30AM 15-Dec-18]
30. http://www.ecpowersystems.com/resources/ground-bars/examination-of-ground-bars-and-their-purposein-electrical-systems/ [Accessed Time: 9:53 AM 15-Dec-18]
31. http://de.slideshare.net/AchmadFauzi24/huawei-gsm-principles[Accessed Time: 8:00PM 15-Dec-18]
32. http://docplayer.net/39826471-Openmsc-product-report.html [Accessed Time: 8:30 PM 15-Dec-18]
33. http://brenclosures.com.au/telecoms_trans.htm[Accessed Time: 9:35 PM 15-Dec-18]
34. http://www.esru.strath.ac.uk/EandE/Web_sites/10-11/Mobile_mast/bts.htm[Accessed Time: 9:56 PM 15-Dec-18]
35. http://www.dieselserviceandsupply.com/How_Generators_Work.aspx [Accessed Time: 10:09 PM 15-Dec-18]
36. https://en.wikipedia.org/wiki/Microwave_antenna (11:50 PM 15-Dec-18)
37. http://www.cinterion.com/m2m-glossary.html(6:00AM 16-Dec-18)
38. http://www.scribd.com/doc/10326000/Putas-Asesinas-Bolanos-Roberto[Accessed Time: 8:00 AM 16-Dec-18]
39. https://www.daenotes.com/electronics/microwave-radar/digital-microwave-communication-equipment[Accessed Time: 8:50 AM 15-Dec-18]
40. https://wikivisually.com/wiki/TalkTalk_Group[Accessed Time: 6:00 AM 16-Dec-18]
41. http://www.lexproducts.com/specfeed.htm[Accessed Time: 7:30 AM 16-Dec-18]
42. http://www.jbisa.nl/download/?noGzip=1&id=15043720[[Accessed Time: 7:50 AM 16-Dec-18]
43. http://www.scribd.com/doc/37142214/Ei-Gsm-Ericsson-Bts-At[Accessed Time: 8:05 AM 16-Dec-18]
44. https://www.journalajst.com/sites/default/files/6041.pdf [Accessed Time: 8:50 AM 16-Dec-18]
45. http://www.randakksblog.com/comprehensive-gl1000-charging-system-troubleshoot[Accessed Time: 9:00 AM 13-Dec-18]

46. http://docslide.us/documents/3900-series-base-station-technical-description-draft-apdf-en.html[Accessed Time: 9:50 AM 17-Dec-18]
47. https://howlingpixel.com/i-en/3G [Accessed Time: 1:50 PM 17-Dec-18]