TECHNICAL PROPOSAL

Microwave Communication Radio Systems

Prepared by Rawafid for Technology (R4T) L.L.C.
PO Box 41849, Abu Dhabi – UAE

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"منظمات التراسل الراديو بموجات مايكرووية"

يتراوح تردد موجات التراسل بالموجات الكهرومغناطيسية الدقيقة بين 300 ميكا هرتز و 3 جيجا هرتز وتتعامل أغلب شبكات التراسل الراديوية الأرضية بين 300 ميكا هرتز و 3 جيجا هertz. ولأن هذا النطاق من التردد يتطلب الرؤية المباشرة في خط النظر (Line Of Site: LOS) لابد من استخدام الرؤية المباشرة عبر إنجاز مستوى الأرض عند إستبداد المسافات وأن يتطلب إنتاج البرج أيضا مع ذلك على كافه الفعارات الصادرة لإشارات التراسل كالنواحي العالية والاشجار والثقوب والأجراء. وشبكة التراسل في النهاية غير معقدة التركيب وتكون من طرفيات الربط والمرسلات/المستقبلات والمواقع المثبتة على الأبراج. وتكون رسلتها لإشارات الصوت والصورة والبيانات الرقمية اللازمة لتراسل شبكات الحواسيب بين جهات الإرسال والاستقبال.

وفي عالم الإتصالات تكون إشارات التراسل تناظرية (analog) التي تكون فيها الإشارات متناطرة مع الإشارات الأصلية من صوت أو صورة أو رقمية (digital) حيث تكون الإشارات من زمنين فقط هما "1" و "0". وبالإضافة إلى ذلك التكنولوجي في عالم الإتصالات أخذت الأجهزة تحت المراقبة الأولى في الإستخدام بسبب قابليتها وسهولة إعادة وقابلية عارض الدخول (error rate) وقابلية عارض الدخول (noise) وقابلية عارض الدخول (interference) وقابلية عارض الدخول (signal) وقابلية عارض الدخول (receiver) وإمكانية إجراء مقارنة بإجهاز التراسل التناظرية الأولي.

وفي العصر فإن شبكات التراسل بالموجات الكهرومغناطيسية الدقيقة تعطي عدد خواص تغلب استخدامها على الشبكات الضيقة لعدة تحويلات وتوزيع سرعات الصوت والissentاد، قلبية الكثافة، واندماجها فيดา أثر العوارض الطبيعية والكوارث. وبدأت اليوم إستخدامها شائعا في عدد تطبيقات للإتصالات كالهاتف الخلوي (الاتصال) وشبكات علاقات النقل والتوصيل ومزودي خدمة الإنترنت وغيرها. وقدرة توفر الوصول إلى مسافات تصل حتى 100 كيلومتر (بدون مكارات تقوية) ودرستها على إرسال حزم تصل حتى 70 ميغا بايت مثله يكون هذا النوع من التراسل تقنية فعالة ورعاية ديناميكية رغبة. وترحب هذا شركة روافد لتكنولوجيا بإير إتصال لتوزيع وتركيب هذا النوع من الشبكات بالكامل وتوفر تقنيتها مع التدريب.

لإعلان على المقترحات الأخرى لشركة روافد لتكنولوجيا: نصف النص على الموقع الإلكتروني

Email: md@r4t.me
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1- Introduction

Microwave frequencies range from 300 MHz to 30 GHz, corresponding to wavelengths of 1 meter to 1 centimeter. These frequencies are useful for terrestrial and satellite communication systems, both fixed and mobile. In the case of point-to-point radio links, antennas are placed on a tower or other tall structure at sufficient height to provide a direct, unobstructed line-of-sight (LOS) path between the transmitter and receiver sites. In the case of mobile radio systems, a single tower provides point-to-multipoint coverage, which may include both LOS and non-LOS paths. LOS microwave is used for both short- and long-haul telecommunications to complement wired media such as optical transmission systems. Applications include local loop, cellular back haul, remote and rugged areas, utility companies, and private carriers. Early applications of LOS microwave were based on analog modulation techniques, but today’s microwave systems used digital modulation for increased capacity and performance.

The basic components required for operating a radio link are the transmitter, towers, antennas, and receiver. Transmitter functions typically include multiplexing, encoding, modulation, up-conversion from base band or intermediate frequency (IF) to radio frequency (RF), power amplification, and filtering for spectrum control. Receiver functions include RF filtering, down-conversion from RF to IF, amplification at IF, equalization, demodulation, decoding, and de-multiplexing. To achieve point-to-point radio links, antennas are placed on a tower or other tall structure at sufficient height to provide a direct, unobstructed line-of-sight (LOS) path between the transmitter and receiver sites.

2- Nature Limitation Facts

Various phenomena associated with propagation, such as multi path fading and interference that affects microwave radio performance. The modes of propagation between two radio antennas may include a direct, line-of-sight (LOS) path but also a ground or surface wave that parallels the earth's surface, a sky wave from signal components reflected off the troposphere or ionosphere, a ground reflected path, and a path diffracted from an obstacle in the terrain. The presence and utility of these modes depend on the link geometry, both distance and terrain between the two antennas, and the operating frequency. For frequencies in the microwave (~2 – 30 GHz) band, the LOS propagation mode is the predominant mode available for use; the other modes may cause interference with the stronger LOS path. Line-of-sight links are limited in distance by the curvature of the earth, obstacles along the path, and free-space loss. For frequencies below 2 GHz, the typical mode of propagation includes non-line-of-sight (NLOS) paths, where refraction, diffraction, and reflection may extend communications coverage beyond LOS distances. The performance of both LOS and NLOS paths is affected by several phenomena, including free-space loss, terrain, atmosphere, and precipitation.
3- Analogue and Digital Transmissions

In the world of electrical communications there are two ways to transmit a message between two points: with an analog signal or a digital signal. With analog transmission, the signal carrying the information is continuous; for example, when talking into the telephone, a voice is transmitted as a voltage signal of continuously varying amplitude and frequency. With digital transmission, the signal is a series of discrete levels, or pulses (1's and 0's) corresponding to "on" and "off", respectively.

One very important characteristic of digital microwave radio transmission is its immunity to noise. Noise refers to unwanted electromagnetic waveforms that corrupt a message signal. Noise is inevitable in electrical communications systems. In order to transmit an electrical signal over a long distance it is necessary to boost the signal level at intervals along the transmission path; this is the job of a device called a repeater.

Digital microwave radio systems are used to transmit and receive information between two points that can be separated by up to 60 kilometers (and sometimes farther, say 100 kilometres) in a telecommunications network. The information can be voice, data, or video as long as it is in a digital format. A typical microwave radio consists of three basic components: a digital modem for interfacing with digital terminal equipment, a radio frequency (RF) unit for converting a carrier signal from the modem to a microwave signal, and an antenna to transmit and receive the signal. The combination of these three components is referred to as a radio terminal. Two terminals are required to establish a microwave communications link, commonly referred to as a microwave hop.

4- Benefits and Advantages

Point To Point (PTP) microwave radio system offers several advantages over cable-based transmission. The system is simpler, faster, more feasible and more flexible to implement than cable systems. Because there is no buried cable involved, microwave systems do not require right-of-way, and they are not susceptible to cable cuts. Microwave is also easy to move if there is a change in a network.

Some of the advantages that Point-to-Point (PTP) microwave systems offer include:

- Faster network rollout and implementation (no trenches to dig)
- Lower cost of ownership over time or return on investment (ROI)
- Increased network design flexibility
- Full management & control over operator owned network
- Relatively low initial investment
- Low operating costs
- No long outages due to so-called “back-hoe fade” (accidentally digging up cables)
- Better resilience to natural disasters.
Microwave systems are used by businesses of all types for many different applications. Some examples include:

- **Mobile Carriers** use microwave for base-station backhaul of voice traffic for route to local PSTN.

- **Telephone companies**, use microwave for redundant backup on critical paths, accessing remote areas to supply voice and data services, provide dedicated access to corporate users with high traffic volume, or for creating and completing VPNs for corporate users.

- **Internet Service Providers** are using microwave to create their own networks to reduce their dependence on telephone companies to gain access to their customers.

### 5- Application Examples

**Cellular:**
Cellular carriers often face aggressive schedules to provide service for customers and to generate immediate revenue. In order to turn up their networks, cellular carriers need to connect their cell sites to switching stations. To make this connection, they usually choose microwave, because it is reliable and can be commissioned within a day.

**Local Distribution:**
Many businesses use microwave in their private networks because it's the fastest way for them to install digital communications. Microwave offers businesses a low cost, high security alternative to traditional communications systems.

**Control & Monitoring:**
Public transport organizations, railroads and other public utilities are major users of microwave. These companies use microwave to carry control and monitoring information to and from power substations, pumping stations, and switching stations.

**Long Distance Carrier Connections:**
A significant part of the cost of a long distance telephone call is in the local connection to a long distance carrier. Microwave radio links the end user to the long distance carrier, reducing the cost of this connection. In areas where long distance service is available but there are no local lines, microwave can provide the "last mile" connection.

### 6- Technology Overview

The design of microwave radio systems involves engineering of the path to evaluate the effects of propagation on performance, development of a frequency allocation plan, and proper selection of radio and link components. This design process must ensure that
outage requirements are met on a per link and system basis. The frequency allocation plan is based on four elements: the local frequency regulatory authority requirements, selected radio transmitter and receiver characteristics, antenna characteristics, and potential intra-system and inter-system RF interference.

Proper microwave system design requires a thorough understanding of the fundamentals as well as a detailed knowledge of the entire design process. This includes conceptual planning, equipment selection, transmission link design, propagation and frequency planning, and an analysis of interference potential/mitigation.

Before getting to the nuts and bolts of designing a link, some fundamental terms and concepts need to be reviewed:

**Free Space Loss:**

As signals spread out from a radiating source, the energy is spread out over a larger surface area. As this occurs, the strength of that signal gets weaker. Free space loss (FSL), measured in dB, and specifies how much the signal has weakened over a given distance. Figure 1 shows the formula to calculate FSL and what the theoretical loss would be at sample distances. The type of antenna used has no effect on FSL, since at any appreciable distance all antennas look like a point source radiator.

![Figure 1 - Free Space Loss](image)

**Fresnel Zone:**

Radio waves travel in a straight line, unless something refracts or reflects them. But the energy of radio waves is not “pencil thin.” They spread out the farther they get from the radiating source like ripples from a rock thrown into a pond.

The area that the signal spreads out into is called the Fresnel zone. If there is an obstacle in the Fresnel zone, part of the radio signal will be diffracted or bent away.
from the straight-line path. The practical effect is that on a point-to-point radio link, this refraction will reduce the amount of RF energy reaching the receiving antenna.

The thickness or radius of the Fresnel zone depends on the frequency of the signal, the higher the frequency, the smaller the Fresnel zone. Figure 2 illustrates how the Fresnel zone is fattest in the middle. As with FSL, the antennas used have no effect on the Fresnel zone.

![Fresnel Zone Illustration]

**Figure 2**

**Received Signal Level:**

Received signal level is the actual received signal level presented to the antenna port of a radio receiver from a remote transmitter.

**Receiver Sensitivity:**

Receiver sensitivity is the weakest RF signal level that a radio needs receive in order to demodulate and decode a packet of data without errors.

**Antenna Gain:**

Antenna gain is the ratio of how much an antenna boosts the RF signal over a specified low-gain radiator. Antennas achieve gain simply by focusing RF energy.

**Transmit Power:**

The transmit power is the RF power coming out of the antenna port of a transmitter. It does not include the signal loss of the coax cable or the gain of the antenna.

**Effective Isotropic Radiated Power (EIRP):**
EIRP is the actual RF power as measured in the main lobe (or focal point) of an antenna. It is equal to the sum of the transmit power into the antenna (in dBm) added to the dBi gain of the antenna. Since it is a power level, the result is measured in dBm.

Figure 3 shows how +24 dBm of power can be “boosted” to +48 dBm or 64 Watts of radiated power.

System Operating Margin (SOM):

SOM is the difference (measured in dB) between the nominal signal level received at one end of a radio link and the signal level required by that radio to assure that a packet of data is decoded without error (see Figure 4).

In other words, SOM is the difference between the signal received and the radio’s specified receiver’s sensitivity. SOM is also referred to as link margin or fade margin.
Multiple Path Interference:

When signals arrive at a remote antenna after being reflected off the ground or refracted back to earth from the sky (sometimes called ducting), they will subtract (or add) to the main signal and cause the received signal to be weaker (or stronger) throughout the day.

Signal to Noise Ratio (SNR):

SNR is the ratio (usually measured in dB) between the signal level received and the noise floor level for that particular signal. The SNR is really the only thing receiver demodulators really care about. Unless the noise floor is extremely high, the absolute level of the signal or noise is not critical.

Figure 5 illustrates that weaker signals are larger negative numbers. It also graphically shows how the SNR is computed.

![Signal to Noise Ratio (SNR)](image)

Figure 5

Figure 6 below shows the general view of the communication link medium with consideration to the reflected and refracted indirect beams.
Figure 6

7- Architecture

Figure 7
Figure 7 shows the architecture of the link while Figure 8 shows the link terminal (refer to Figure 7). The terminal is modular in design, which helps reduce Mean Time To Repair (MTTR). It is designed for 19-inch rack mounting and is only 2U high for standard configurations. The five main modules housed inside the chassis are the transceiver, modem, motherboard, power supply, and duplexer. Interface cards are fitted into the eight interface slots on the motherboard. Modules are interconnected via several buses on the motherboard. The duplexer is mounted inside or outside the chassis depending on the type and size.

Figure 8

Figure 9
The motherboard contains the Aprisa XE terminal’s central microprocessor and traffic management control functions, including traffic multiplexing and cross-connect. The power PC-based microprocessor interfaces with a Linux-based web server to run the SuperVisor software. Its FPGA (Field Programmable Gate Array) manages the traffic distribution to/from interface ports on the cards fitted to the PCI slots on the motherboard. The motherboard has eight standard PCI slots for interface cards and one extended PCI slot for the modem. The control bus gathers alarms via SNMP (Simple Network Management Protocol) traps and stores them in the web server. LED indicators on the front fascia show the status of the radio link. An alarm I/O port, with two inputs and four outputs, enables operators to connect to external alarm monitoring equipment. The motherboard’s internal power supply delivers +3.3, ± 5 and ± 12 VDC nominal inputs to the terminal elements.

The most available now day’s on earth microwave radio terminals operate in a number of frequency bands from 300 MHz up to 3 GHz carrying Ethernet, voice and data traffic over distances up to 100 kilometers. They are designed to meet the demands of a wide range of low to medium capacity access and backhaul applications. The digital access terminal is a compact, powerful point-to-point linking solution with up to 64 Mbit/s of radio link capacity, and customer-configurable interface options integrated within the radio platform.

The interrelationships between the components are shown below:

![Figure 10](image)

There are two basic configurations for microwave terminals: non-protected and protected or monitored-hot-standby (MHSB). The non-protected configuration is a single standalone terminal. The protected or MHSB configuration has a redundant set of electronics that serves as a back up to the in-service electronics in case of a failure.
8- Approaches & Methods

Whether the link is point-to-point or point-to-multipoint, the first thing to do is to verify that it will have not only clear line of sight, but at least 60 percent of the first Fresnel zone clear of obstructions as well. The longer the distance, the more important this is. If the Fresnel zone is blocked, then a lower signal level on the distant end than expected even if it can literally “see” the other antenna in the distance. But even if Fresnel zone is partially blocked, it is still possible to get a link, provided that the system was designed to have a strong signal at the other end of the link.

There are many software packages available that have terrain data and can create a path profile from a set of latitude/longitude coordinates. But these programs can only indicate for certain if a link will not work due to terrain obstruction. A clear path on paper is not a guarantee that the link will work, since it does not show trees or buildings. So even a “clear” link might have 80-foot trees in the way that could block the signal. Possible wasting of time and money if Fresnel zone issues is ignored.

Assuming to have a clear line-of-site and 60 percent of the first Fresnel zone clear (or nearly clear), and doing an SOM calculation, we can test various system designs and scenarios to see how much fade margin (or “safety cushion”) the link will theoretically have.

Figure 11 illustrates a sample SOM calculation on a point-to-point link. It presumes that the antennas are aimed at each other properly (i.e., they are in each others’ main lobe). To calculate SOM in the example, start with the transmit power (+24 dBm), subtract the coax cable loss (1 dB), and add the transmit antenna gain (24 dBi). This gives the EIRP factor:

$$\text{EIRP = TX Power - Coax Cable Loss + TX Antenna Gain.}$$

Then subtract the FSL (130 dB), add the receiver antenna gain (24 dBi), subtract the coax cable loss (1dB) and you get the signal reaching the receiver:

$$\text{RX Signal = EIRP - FSL + RX Antenna Gain – Coax Cable Loss}$$

Compute the difference between the received signal and the radio’s receiver sensitivity to determine the SOM. In this example, the received signal is –60 dBm and the receiver’s sensitivity is –83 dBm giving a theoretical SOM of 23 dB.
Regarding the minimum SOM needed, there is no absolute answer to this question, but the higher it is, the better. Most engineers agree that 20 dB or more is quite adequate. Some think as low as 14 dB is still good. Others operate systems down to 10 dB or less.

9- SYSTEM COMPONENTS AND MANAGING S/W

The main system components used in a typical Microwave Radio Link communication includes the following:

a) Radio Link  
b) Antenna  
c) Coaxial Feeder Cables  
d) Power Supply  
e) Multiplex & Ancillary Equipments  
f) Test & Maintenance Equipments

Most generic link managing software are pre-loaded into an integrated web-server within the terminal and run on any Java-enabled web browser. Those software can be used as example for:

- Display and configure terminal parameters  
- View the terminal alarms  
- Monitor the performance and status of the link  
- Upgrade the terminal software  
- Save and load configuration files  
- Save performance and error information to a log file
10- Summary and Conclusion

Microwave radio is a flexible and cost-effective alternative for transmission of voice, data, and video services in all parts of a fixed or wireless mobile network, including applications for the backhaul or direct access services. With the scale and flexibility of today’s new radio technology, implementing a microwave network is more economical and easier than ever. A typical microwave link can be installed in a short period of time. Enhancements in wireless technology have also allowed higher order modulation schemes to be implemented that offer spectral efficiencies not possible in higher frequency radios just a few years ago. These efficiencies permit less bandwidth for the same capacity or higher capacities within the same bandwidth compared to older models. All this gives network designers and operators many more choices to build and maintain their networks.

Microwave Radio Link Communication is a flexible range of voice, data and IP interfaces, giving enterprises complete control over their networks. It is ideal for linking branch offices to head offices, communicating between different buildings in a university or hospital network or backhauling a campus Wi-Fi network to the wider area network. Suitable for even the most bandwidth demanding applications. Using licensed frequency bands, it reliably makes and maintains an interference free connection despite the problems of harsh weather conditions, long distances to rural locations, or links over water or round building obstacles in dense city environments.

Radio Link innovative technology can link distances over 100 kilometers in a single hop and delivers up to 65Mbit/s. Ideal for connecting rural and remote parts of networks, it provides a significantly cheaper alternative to copper-wire and fibre deployment and considerable technical and cost benefits over satellite technology. Integrated networking features allow both IP (Ethernet) and traditional voice and data services to be supported on a converged, future proofed wireless platform.

_________________________________

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Appendix 1

Towers Construction

**Prelude:** Most tower structures are designed to withstand a forceful wind speed that occurs on the average of every 50 years. This wind speed is then escalated, with height to a much higher wind speed at the top of the structure. A gust factor to account for the varying nature of the wind is also incorporated into the design of the structure. The same factors used in building design are incorporated into both the structure and foundation design of the tower.

**Monopole, Self-Support Towers & Guyed Towers**

a) **Monopole Towers**
Ranging in height from 25 to 125 FT (7.6 to 38m) monopole consists of a single pole, approximately 3FT (1m) in diameter at the base, narrowing to roughly 1.5FT (0.5m) at the top. Monopoles are generally used in rural areas or in areas where buildings are not of sufficient height to meet line of sight transmission requirements. The efficiency of the design allows it to be an economical option for a range of heights to up to 40m. The monopole towers can be used for microwave links and telecommunication applications.
b) **Guyed Towers**

Guyed Towers are slender, generally three or four sided lattice construction, and are uniform in dimension over their length. They are maintained in their vertical position by guy wires, which are attached at various levels on the tower and anchored to the concrete on the ground. Under normal circumstances, a guyed tower requires a radius of 80 percent of the height of the tower. Guy stay wires stretch over time and the tensions within these assemblies should be adjusted from time to time.

![Guyed Tower Diagram](image1.png)

![Guyed Tower Image](image2.png)

c) **Self Supporting Towers**

Self Supporting towers stand on their own and require a base spread of approximately 13 percent of their height. Table below shows the minimum radius of the circular surface required for the self support tower erection. These towers are relatively inexpensive up to about 100FT (35m) or so but become very costly as their height increases.

![Self-Supporting Tower Diagram](image3.png)

![Self-Supporting Tower Image](image4.png)
Steel (galvanized after fabrication) for the most part is used as the material for the construction of towers. Galvanized Guy or bridge strand guys are generally selected for the guy stays that support the guyed tower. The lattice of the tower can be made using a variety of steel shapes and connection types.

A common make up for a multiple microwave dish and line support tower would be angle leg, angle bracing, and bolted construction, with a climbing ladder inside the structure. This configuration offers relatively low manufacturing cost, significant strength, high stability, ease of antenna attachment.

It is important to ensure that nobody walks in front of the antenna, since that could interrupt the traffic on the microwave link and be hazardous to the persons health.

Tower Erection Time Lines

<table>
<thead>
<tr>
<th>Self-supported tower height (feet)</th>
<th>Required area for three-leg tower (radius in feet)</th>
<th>Required area for four-leg tower (radius in feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>13.8</td>
<td>15.4</td>
</tr>
<tr>
<td>100</td>
<td>17.3</td>
<td>20.5</td>
</tr>
<tr>
<td>150</td>
<td>21.9</td>
<td>25.4</td>
</tr>
<tr>
<td>200</td>
<td>26.4</td>
<td>30.6</td>
</tr>
<tr>
<td>300</td>
<td>34.8</td>
<td>40.8</td>
</tr>
</tbody>
</table>

Laying a stable foundation is the first concern in erecting a sturdy communication tower. Once concrete is poured, a test should be performed every week to determine the foundation strength of the curing material. At seven days, the concrete should measure 70% of its estimated strength. Concrete reaches its full strength after four to five weeks,
depending on weather conditions. However, tower assembly on ground can start before the foundation is completed and minor loading of the concrete is possible after one week.

Unauthorized access to towers can be prevented by fencing with barbed wire, removing ladders, installing flat plates around the lower part of the construction.

Many types of fall protection can be incorporated such as guiding tracks with wire and wheel or simply a climbing cage around the ladder. Service platforms and rest platforms are compulsory accessories in many developed countries.

The tower is painted mainly for corrosion protection. A compulsory aviation warning color scheme is deployed in some countries.

Different types of aviation warning lights are required in various countries, including dusk activated relays. It is widely accepted that lighting protection can be connected to earth through the tower mast. A maximum resistance of 10 Ohm is needed to ground.

The most vital information that has to be provided to the tower manufacturer is as follows:

a) Tower Load: - For the microwave applications, tower loading of the antenna mounting structures includes antenna mounting structures, antennas (immediate & future requirements), wind, ice, wave guides, co-axial cables, platforms, outdoor radio units and so on. The detailed loading requirements should be given to the tower designer and if climatic conditions are unknown, assumptions must be made based on local statistics.

b) Wind Speed: - Some times referred to as wind load, this is the force that wind has on the towers and the antennas

c) Ice Load: Also known as radial ice, this is the amount of ice in inches formed around each tower member.

d) Soil report: This report details the soil condition present at the site and helps to determine what type of foundation is needed.

**Height of Antenna Tower**

The height of an antenna depends of many factors:
Add these values to find the Antenna Height.

*Distance between the sites: Earth curvature*, the longer the link, the higher the antenna needs to be.

*The Fresnel Zone*: This is an electromagnetical phenomenon, where light or radio signals get diffracted or bent from solid objects near their path. The 60% of Fresnel Zone Values (Accepted clearing on path). Add this to the Earth curvature height.

*Objects in the path*: At a frequency of 2.4 GHz, a clear line of sight (LOS) is needed. Tree tops will reflect or ground the signal. The theory is that the height of the tallest object in the path of the signal should be added to the Fresnel Zone and Earth Curvature clearance heights. In your case, you should have to check the height of the trees, hills, buildings or any object on the link path and add this to the measurement for the total of the tower height.

The above three conditions make up the Radio Line of Sight.
Appendix 2

Antennas

**Prelude:** Selecting and setting antennas are important considerations in the system design. There are three main types of directional antenna that are commonly used with the radios: parabolic grid, Yagi, and corner reflector antennas. The antenna that should be used for a particular situation is determined primarily by the frequency of operation and the gain required to establishing a reliable link.

Parabolic Grid Antennas: -

<table>
<thead>
<tr>
<th>Factor</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>Often used in 1350-2700 MHz bands</td>
</tr>
<tr>
<td>Gain</td>
<td>Varies with size (17 dBi to 30 dBi typical)</td>
</tr>
<tr>
<td>Wind loading</td>
<td>Can be significant</td>
</tr>
<tr>
<td>Tower aperture required</td>
<td>Can be significant</td>
</tr>
<tr>
<td>Size</td>
<td>Range from 0.6 m to 3 m diameter</td>
</tr>
<tr>
<td>Front to back ratio</td>
<td>Good</td>
</tr>
<tr>
<td>Cost</td>
<td>High</td>
</tr>
</tbody>
</table>

Yagi Antennas: -

<table>
<thead>
<tr>
<th>Factor</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>Often used in 330-960 MHz bands</td>
</tr>
<tr>
<td>Gain</td>
<td>Varies with size (typically 11 dBi to 16 dBi)</td>
</tr>
<tr>
<td>Stackable gain increase</td>
<td>2 Yagi antennas (+ 2.8 dB)</td>
</tr>
<tr>
<td></td>
<td>4 Yagi antennas (+ 5.6 dB)</td>
</tr>
<tr>
<td>Wind loading</td>
<td>Less than a parabolic grid antenna</td>
</tr>
<tr>
<td>Tower aperture required</td>
<td>Unstacked: Less than a parabolic grid antenna</td>
</tr>
<tr>
<td></td>
<td>Stacked: about the same as a parabolic grid antenna</td>
</tr>
<tr>
<td>Size</td>
<td>Range from 0.6 m to 3 m in length</td>
</tr>
<tr>
<td>Front to back ratio</td>
<td>Low</td>
</tr>
<tr>
<td>Cost</td>
<td>Low</td>
</tr>
</tbody>
</table>
Corner Reflector Antennas: -

<table>
<thead>
<tr>
<th>Factor</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>Often used in 330-960 MHz bands</td>
</tr>
<tr>
<td>Gain</td>
<td>Typically 10 dBi</td>
</tr>
<tr>
<td>Wind loading</td>
<td>Less than a parabolic grid antenna</td>
</tr>
<tr>
<td>Tower aperture</td>
<td>About the same as a parabolic grid antenna</td>
</tr>
<tr>
<td>Size</td>
<td>Range from 0.36 m to 0.75 m in length</td>
</tr>
<tr>
<td>Front to back ratio</td>
<td>High (typically 30 dB)</td>
</tr>
<tr>
<td>Beamwidth</td>
<td>Broad (up to 60°)</td>
</tr>
<tr>
<td>Cost</td>
<td>Medium</td>
</tr>
</tbody>
</table>

Antenna Setting: -

When setting antennas, consider the following points:

- A site with a clear line of sight to the remote terminal is needed. Pay particular attention to trees, buildings, and other obstructions close to the antenna site.

  ![Example of a clear line-of-sight path](image)

- Any large flat areas that reflect RF energy along the link path, for instance, water, could cause multi-path fading. If the link path crosses a feature that is likely to cause RF reflections, shield the antenna from the reflected signals by positioning it on the far side of the roof of the equipment shelter or other structure.
- The antenna site should be as far as possible from other potential sources of RF interference such as electrical equipment, power lines and roads.

- The antenna site should be as close as possible to the equipment shelter.
Appendix 3

Test Equipments

**Prelude:**

**Bit Error Rate Tests:**

The BER test is a measure of the stability of the complete link. The BER results of a link can be asymmetrical (that is, different at each end). A Bit Error Rate (BER) test can be conducted on the bench (See Bench Setup explained below). Attach the BER tester to the interface port(s) of one terminal, and either another BER tester or a loop back plug to the corresponding interface port of the other terminal. This BER test can be carried out over the Ethernet, E1 / T1, V.24 or HSS interfaces. It will test the link quality with regard to user payload data.

**Bench Setup:**

Before installing the link in the field, it is recommended that bench-test be carried out for the link. A suggested setup for basic bench testing is shown below:

When setting up the equipment for bench testing, note the following:

Earthing: the terminal should be earthed at all times. The terminal earth stud must be connected to a protection earth.

Attenuators: in a bench setup, there must be 60 - 80 dB at up to 3 GHz of 50 ohm coaxial attenuation (capable of handling the transmit power of +35dBm) between
the terminals’ N type antenna connectors. This can be achieved with two fixed attenuators fitted to the antennas ‘N’ connectors and a variable attenuator with a ≥ 60 dB range. Other attenuator values as long as the transmit power output level (max +33 dBm) and the receiver signal input (max -20 dBm).

Cables: use double-screened coaxial cable that is suitable for use up to 3 GHz at ≈ 1 meter.

E1 BER Tester

E1 BER (Bit Error Rate) Tester is a multi-functional, handheld E1 line test instrument, specially designed for E1 PCM line access, maintenance, inspection and acceptance testing. The tester provides BER testing, alarm analysis, and signal analysis useful in R&D, production, installation and maintenance of SDH, PDH, PCM, and DATA Protocol Conversion.

RF Analyzer

The RF Analyzer is an integrated handheld instrument for wireless network installation and maintenance. It combines cable/antenna analysis, spectrum analysis, interference analysis, power meter measurements, vector network analysis, and a vector voltmeter into one rugged, compact, lightweight and weather-resistant package. Standard accessories include AC/DC adapter, battery, soft carrying case, user manual and a Data Link software.