MICROWAVE TRANSMISSION LINE AND IT’S PERFORMANCE ANALYSIS

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APPROVAL

This project, titled “Microwave Transmission Line and its Performance Analysis”, submitted by Md. Azimul Islam and Md. Rafiqul Islam and Mohammad Rasel to the Department of Electronics and Telecommunication Engineering, Daffodil International University, has been accepted as satisfactory for the partial fulfillment of the requirements for the degree of B.Sc. in Electronics and Telecommunication Engineering and approved as to its style and contents. The presentation has been held on 26 February,2011.

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We hereby declare that, this project report has been done by us under the supervision of Mr. Md. Mirza Golam Rashed, Assistant Professor, Department of ETE Daffodil International University. We also declare that neither this project nor any part of this project has been submitted elsewhere for award of any degree or diploma.

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ABSTRACT

Microwave communication is the transmission of signals via radio using a series of microwave towers. Microwave communication is known as a form of “line of sight” communication, because there must be nothing obstructing the transmission of data between these towers for signals to be properly sent and received. Microwave radio transmission is commonly used by communication systems on the surface of the Earth, in satellite communications, and in deep space radio communications. Other parts of the microwave radio band are used for radars, radio navigation systems, sensor systems, and radio astronomy.

This project which consists of three major parts, first part is the VSWR. Voltage standing waves are the result of reflected RF energy. As the VSWR approaches 1.00:1 VSWR of 1:1 means that there is no power being reflected back to the source. This is an ideal situation. That rarely, if ever, is seen. In the practical field, a VSWR of 1.35:1 (or simply 1.35) is considered excellent in most cases. At a VSWR of 2.0, approximately 10% of the power is reflected back to the source. Not only does a high VSWR mean that power is being wasted, the reflected power can cause problems such as heating cables. The Second part is DTF which is distance to fault Measurement. If a 60 meter transmission line gets VSWR of 2 or more than 2 at the point of 55 meter then have to understand that DTF occur at the point of 55 meter. The analyzer can locate faults and discontinuities on cables and transmission lines. The last part is RSL which is stand for receive signal level. If the RSL value is (32-40) then the signal transfer level will be very good otherwise receive signal level will not be good. It is expressed in voltage per length or signal power received by a reference antenna.

High powered transmissions, such as those used in broadcasting, are expressed in dB-millivolts per metre (dBmV/m). For very low-power systems, such as mobile phones, signal strength is usually expressed in dB-microvolt’s per meter (dBµV/m).

In summary this project has proposed and then solved several resource allocation problems in transmission line.

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INTRODUCTION

1.1 Overview:

Microwave system has rapidly developed in the last eight years. Micro wave communication is now being used very widely. All these require rapid development of microwave components and equipment. In the last four decades there has been very fast progress. Microwave radio is totally transparent to the information carried across the link, which can be voice, data, video or a combination of all three.Transport can be in a variety of formats including more traditional circuit switched time division multiplex (TDM), more recent packet based data protocols such as ATM, frame relay or IP, often carried using the ubiquitous Ethernet. Transmission of voice and data signals in digital form on microwave links, as in the 2-gigahertz common-carrier bands, pulse-code modulation is used.

1.2 Microwave:

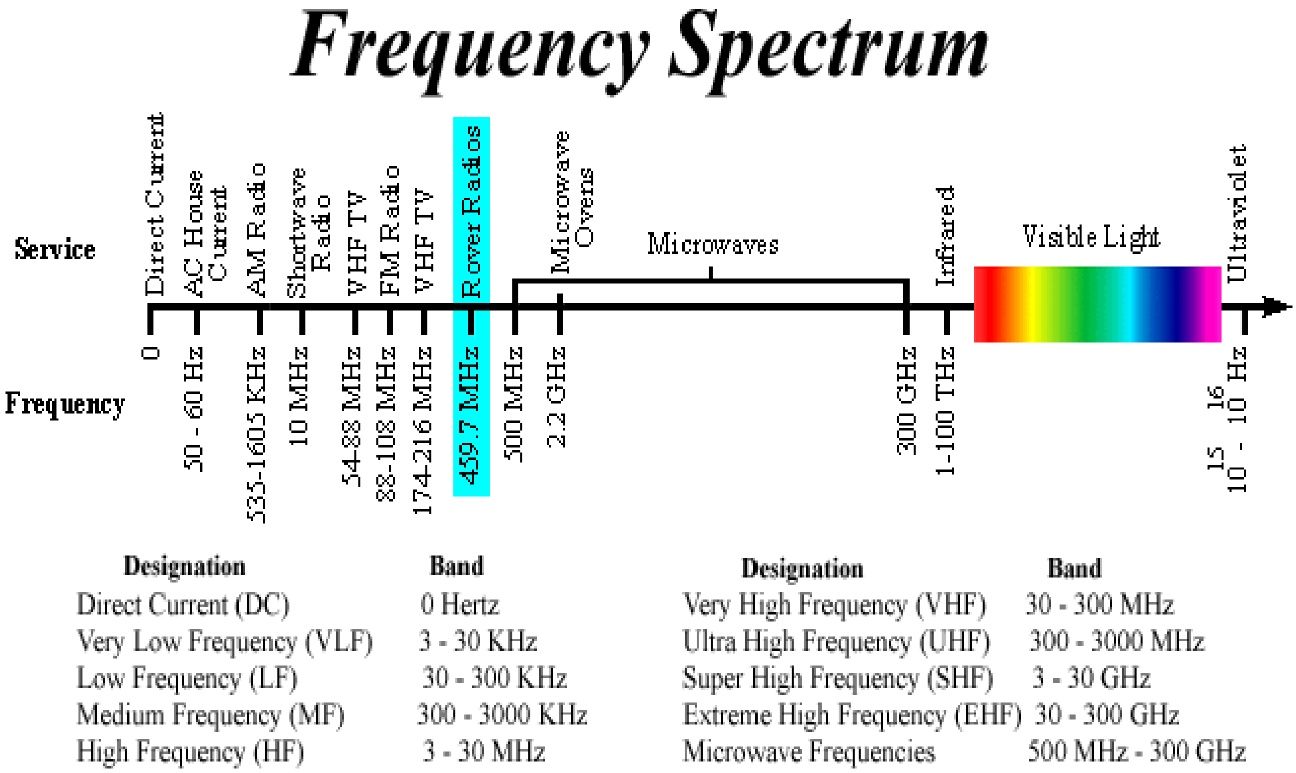
Microwaves are electromagnetic waves with wavelengths ranging from as long as one meter to as short as one millimeter, or equivalently, with frequencies between 300 MHz (0.3 GHz) and 300 GHz. This broad definition includes both UHF and EHF (millimeter waves), and various sources use different boundaries.[2] In all cases, microwave includes the entire SHF band (3 to 30 GHz, or 10 to 1 cm) at minimum, with RF engineering often putting the lower boundary at 1 GHz (30 cm), and the upper around 100 GHz (3mm).[1]

1.2.1 Microwave sources:

Vacuum tube devices operate on the ballistic motion of electrons in a vacuum under the influence of controlling electric or magnetic fields, and include the magnetron, klystron, traveling-wave tube (TWT), and gyrotron. These devices work in the density modulated mode, rather than the current modulated mode. This means that they work on the basis of clumps of electrons flying ballistically through them, rather than using a continuous stream.[2]

1.2.2 Radio frequency:

Radio frequency (RF) is a rate of oscillation in the range of about 30 KHz to 300 GHz, which corresponds to the frequency of electrical signals normally used to produce and detect radio waves. RF usually refers to electrical rather than mechanical oscillations, although mechanical RF systems do exist.



Designation	Band	Designation	Band
Direct Current (DC)	0 Hertz	Very High Frequency (VHF)	30 - 300 MHz
Very Low Frequency (VLF)	3 - 30 KHz	Ultra High Frequency (UHF)	300 - 3000 MHz
Low Frequency (LF)	30 - 300 KHz	Super High Frequency (SHF)	3 - 30 GHz
Medium Frequency (MF)	300 - 3000 KHz	Extreme High Frequency (EHF)	30 - 300 GHz
High Frequency (HF)	3 - 30 MHz	Microwave Frequencies	500 MHz - 300 GHz

Fig. 1.1 Frequency Spectrum

1.3 Communication:

Before the advent of fiber-optic transmission, most long distance telephone calls were carried via networks of microwave radio relay links run by carriers such as AT&T Long Lines. Starting in the early 1950s, frequency division multiplex was used to send up to 5,400 telephone channels on each microwave radio channel, with as many as ten radio channels combined into one antenna for the hop to the next site, up to 70 km away.

Metropolitan area networks: MAN protocols, such as WiMAX (Worldwide Interoperability for Microwave Access) based in the IEEE 802.16 specification. The IEEE 802.16 specification was designed to operate between 2 to 11 GHz. The commercial implementations are in the 2.3 GHz, 2.5 GHz, 3.5 GHz and 5.8 GHz ranges.

Wide Area Mobile Broadband Wireless Access: MBWA protocols based on standards specifications such as IEEE 802.20 or ATIS/ANSI HC-SDMA (e.g. iBurst) are designed to operate between 1.6 and 2.3 GHz to give mobility and in-building penetration characteristics similar to mobile phones but with vastly greater spectral efficiency.

Some mobile phone networks, like GSM, use the low-microwave/high-UHF frequencies around 1.8 and 1.9 GHz in the Americas and elsewhere, respectively. DVB-SH and S-DMB use 1.452 to 1.492 GHz, while proprietary/incompatible satellite radio in the U.S. uses around 2.3 GHz for DARS.

Microwave radio is used in broadcasting and telecommunication transmissions because, due to their short wavelength, highly directional antennas are smaller and therefore more practical than they would be at longer wavelengths (lower frequencies). There is also more bandwidth in the microwave spectrum than in the rest of the radio spectrum; the usable bandwidth below 300 MHz is less than 300 MHz while many GHz can be used above 300 MHz. Typically, microwaves are used in television news to transmit a signal from a remote location to a television station from a specially equipped van. See broadcast auxiliary service (BAS), remote pickup unit (RPU), and studio/transmitter link (STL).

Most satellite communications systems operate in the C, X, Ka, or Ku bands of the microwave spectrum. These frequencies allow large bandwidth while avoiding the crowded UHF frequencies and staying below the atmospheric absorption of EHF frequencies. Satellite TV either operates in the C band for the traditional large dish fixed satellite service or Ku band for direct-broadcast satellite. Military communications run primarily over X or Ku-band links, with Ka band being used for Milstar.

1.3.1 Radio communication:

In order to receive radio signals an antenna must be used. However, since the antenna will pick up thousands of radio signals at a time, a radio tuner is necessary to tune in to a particular frequency (or frequency range). This is typically done via a resonator in its simplest form, a circuit with a capacitor and an inductor forming a tuned circuit. The resonator amplifies oscillations within a particular frequency band, while reducing oscillations at other frequencies outside the band.

1.3.2 Line of sight communication:

Line of sight communication is in the VHF and higher frequencies of the RF spectrum where the wavelength is to short to pass over structures and hills, the transmitter and receiver antennas must be in line of site.

1.3.3 Radar:

Radar uses microwave radiation to detect the range, speed, and other characteristics of remote objects. Development of radar was accelerated during World War II due to its great military utility. Now radar is widely used for applications such as air traffic control, weather forecasting, navigation of ships, and speed limit enforcement. A Gunn diode oscillator and waveguide are used as a motion detector for automatic door openers.

1.3.4 Navigation:

Global Navigation Satellite Systems (GNSS) including the Chinese Beidou, the American Global Positioning System (GPS) and the Russian GLONASS broadcast navigational signals in various bands between about 1.2 GHz and 1.6 GHz.

1.3.5 Power:

A microwave oven passes (non-ionizing) microwave radiation (at a frequency near 2.45 GHz) through food, causing dielectric heating by absorption of energy in the water, fats and sugar contained in the food. Microwave ovens became common kitchen appliances in Western countries in the late 1970s, following development of inexpensive cavity magnetrons. Water in the liquid state possesses many molecular interactions which broaden the absorption peak. In the vapor phase, isolated water molecules absorb at around 22 GHz, almost ten times the frequency of the microwave oven.

1.4 Special properties of RF electrical signals:

Electrical currents that oscillate at RF have special properties not shared by direct current signals. One such property is the ease with which they can ionize air, creating a conductive path through it. This property is exploited by 'high frequency' units used in electric arc welding, which use currents at higher frequencies than power distribution uses. Another special property is that RF current cannot penetrate deeply into electrical conductors but flows along the surface of conductors; this is known as the skin effect. Another property is the ability to appear to flow through paths that contain insulating material, like the dielectric insulator of a capacitor. The degree of effect of these properties depends on the frequency of the signals.

1.5 Cellular network:

A cellular network is a radio network distributed over land areas called cells, each served by at least one fixed-location transceiver known as a cell site or base station. When joined together these cells provide radio coverage over a wide geographic area. This enables a large number of portable transceivers (e.g., mobile phones, pagers, etc.) to communicate with each other and with fixed transceivers and telephones anywhere in the network, via base stations, even if some of the transceivers are moving through more than one cell during transmission. Cellular networks offer a number of advantages over alternative solutions:

- increased capacity
- reduced power use
- larger coverage area
- reduced interference from other signals

An example of a simple non-telephone cellular system is an old taxi driver's radio system where the taxi company has several transmitters based around a city that can communicate directly with each taxi.

1.6 GSM History:

During the early 1980s, analog cellular telephone systems were experiencing rapid growth in Europe, particularly in Scandinavia and the United Kingdom, but also in France and Germany. Each country developed its own system, which was incompatible with everyone else's in equipment and operation. This was an undesirable situation, because not only was the mobile equipment limited to operation within national boundaries, which in a unified Europe were increasingly unimportant, but there was also a very limited market for each type of equipment, so economies of scale and the subsequent savings could not be realized. The Europeans realized this early on, and in 1982 the Conference of European Posts and Telegraphs (CEPT) formed a study group called the Groupe Spécial Mobile (GSM) to study and develop a pan-European public land mobile system. Pan-European means European-wide. ISDN throughput at 64Kbs was never envisioned, indeed, the highest rate a normal GSM network can achieve is 9.6kbs. Europe saw cellular service introduced in 1981, when the Nordic Mobile Telephone System or NMT450 began operating in Denmark, Sweden, Finland, and Norway in the 450 MHz range. It was the first multinational cellular system. In 1985 Great Britain started using the Total Access Communications System or TACS at 900 MHz. Later, the West German C-Netz, the French Radiocom 2000, and the Italian RTMI/RTMS helped make up Europe's nine analog incompatible radio telephone systems. Plans were afoot during the early 1980s, however, to create a single European wide digital mobile service with advanced features and easy roaming. While North American groups concentrated on building out their robust but increasingly fraud plagued and featureless analog network, Europe planned for a digital future.

In 1989, GSM responsibility was transferred to the European Telecommunication Standards Institute (ETSI), and phase I of the GSM specifications were published in 1990. Commercial service was started in mid-1991, and by 1993 there were 36 GSM networks in 22 countries . Although standardized in Europe, GSM is not only a

European standard. Over 200 GSM networks (including DCS1800 and PCS1900) are operational in 110 countries around the world. In the beginning of 1994, there were 1.3 million subscribers worldwide which had grown to more than 55 million by October 1997. With North America making a delayed entry into the GSM field with a derivative of GSM called PCS1900, GSM systems exist on every continent, and the acronym GSM now aptly stands for Global System for Mobile communications.

According to the GSM Association as of 2002, here are the current GSM statistics:

* No. of Countries/Areas with GSM System (October 2001) - 172
* GSM Total Subscribers - 590.3 million (to end of September 2001)
* World Subscriber Growth - 800.4 million (to end of July 2001)
* SMS messages sent per month - 23 Billion (to end of September 2001)
* SMS forecast to end December 2001 - 30 Billion per month
* GSM accounts for 70.7% of the World's digital market and 64.6% of the World's wireless market.

The developers of GSM chose an unproven (at the time) digital system, as opposed to the then-standard analog cellular systems like AMPS in the United States and TACS in the United Kingdom. They had faith that advancements in compression algorithms and digital signal processors would allow the fulfillment of the original criteria and the continual improvement of the system in terms of quality and cost. The over 8000 pages of GSM recommendations try to allow flexibility and competitive innovation among suppliers, but provide enough standardization to guarantee proper interworking between the components of the system. This is done by providing functional and interface descriptions for each of the functional entities defined in the system. The United States suffered no variety of incompatible systems as in the different countries of Europe. Roaming from one city or state to another wasn't difficult . Your mobile usually worked as long as there was coverage. Little desire existed to design an all digital system when the present one was working well and proving popular. To illustrate that point, the American cellular phone industry grew from less than 204,000 subscribers in 1985 to 1,600,000 in 1988. And with each analog based phone sold, chances dimmed for an all digital future. To keep those phones working (and producing money for the carriers) any technological system advance would have to accommodate them.

GSM was an all digital system that started new from the beginning. It did not have to accommodate older analog mobile telephones or their limitations. American digital cellular, first called IS-54 and then IS-136, still accepts the earliest analog phones. American cellular networks evolved slowly, dragging a legacy of underperforming equipment with it. Advanced fraud prevention, for example, was designed in later for AMPS, whereas GSM had such measures built in from the start. GSM was a revolutionary system because it was fully digital from the beginning.

1.7 What is GSM:

GSM stands for Global System for Mobile Communication and is an open, digital cellular technology used for transmitting mobile voice and data services. In a GSM network, the following areas are defined:

Cell: Cell is the basic service area: one BTS covers one cell. Each cell is given a Cell Global Identity (CGI), a number that uniquely identifies the cell.

Location Area**:** A group of cells form a Location Area. This is the area that is paged when a subscriber gets an incoming call. Each Location Area is assigned a Location Area Identity (LAI). Each Location Area is served by one or more BSC.

MSC/VLR Service Area**:** The area covered by one MSC is called the MSC/VLR service area.

PLMN: The area covered by one network operator is called PLMN. A PLMN can contain one or more MSC

The BSS is composed of two parts:

The Base Transceiver Station (BTS)

The Base Station Controller (BSC)The BTS and the BSC communicate across the specified Abis interface, enabling operations between components that are made by different suppliers. The radio components of a BSS may consist of four to seven or nine cells. A BSS may have one or more base stations. The BSS uses the Abis interface between the BTS and the BSC. A separate high-speed line (T1 or E1) is then connected from the BSS to the Mobile MSC.

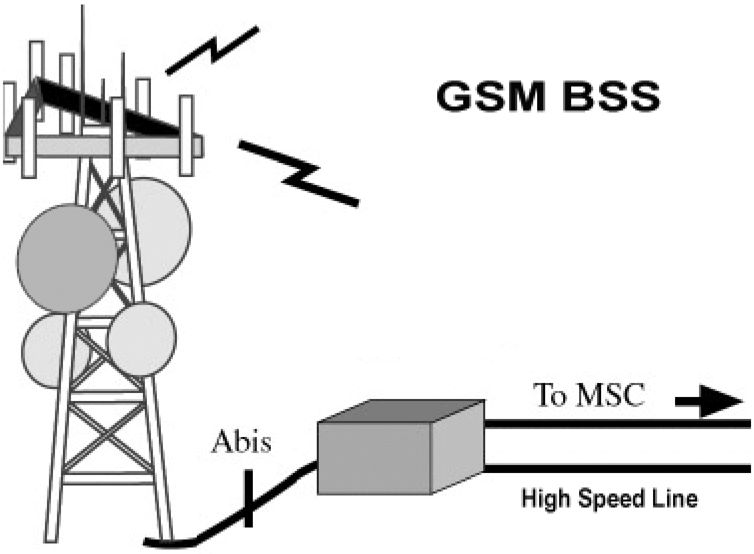


Fig.1.2 Connection between BSS to MSC

1.7.1 The Base Transceiver Station (BTS):

The BTS houses the radio transceivers that define a cell and handles the radio link protocols with the MS. In a large urban area, a large number of BTSs may be deployed.

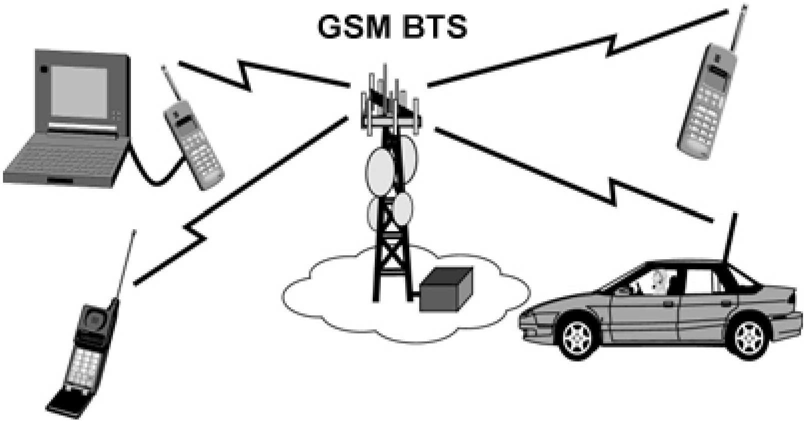


Fig.1.3 Radio link between the BTS and MS

The BTS corresponds to the transceivers and antennas used in each cell of the network. A BTS is usually placed in the center of a cell. Its transmitting power defines the size of a cell. Each BTS has between 1 and 16 transceivers, depending on the density of users in the cell. Each BTS serves a single cell. It also includes the following functions:

- Encoding, encrypting, multiplexing, modulating, and feeding the RF signals to the antenna.
- Transcoding and rate adaptation
- Time and frequency synchronizing
- Voice through full- or half-rate services
- Decoding, decrypting, and equalizing received signals
- Random access detection
- Timing advances
- Uplink channel measurements

1.7.2 The Base Station Controller (BSC):

The BSC manages the radio resources for one or more BTS. It handles radio channel setup, frequency hopping, and handovers. The BSC is the connection between the mobile and the MSC. The BSC also translates the 13 Kbps voice channel used over the radio link to the standard 64 Kbps channel used by the Public Switched Telephone Network (PSDN) or ISDN.

It assigns and releases frequencies and time slots for the MS. The BSC also handles inter cell handover. It controls the power transmission of the BSS and MS in its area. The function of the BSC is to allocate the necessary time slots between the BTS and the MSC. It is a switching device that handles the radio resources. Additional functions include:

- Control of frequency hopping
- Performing traffic concentration to reduce the number of lines from the MSC
- Providing an interface to the Operations and Maintenance Center for the BSS
- Reallocation of frequencies among BTS
- Time and frequency synchronization

- Power management
- Time-delay measurements of received signals from the MS

1.8 GSM frequency bands:

There are fourteen bands defined in 3GPP TS 45.005, which succeeded 3GPP TS 05.05:

System	Band	Uplink (MHz)	Downlink (MHz)	Channel number
T-GSM-380	380	380.2–389.8	390.2–399.8	dynamic
T-GSM-410	410	410.2–419.8	420.2–429.8	dynamic
GSM-450	450	450.4–457.6	460.4–467.6	259–293
GSM-480	480	478.8–486.0	488.8–496.0	306–340
GSM-710	710	698.0–716.0	728.0–746.0	dynamic
GSM-750	750	747.0–762.0	777.0–792.0	438–511
T-GSM-810	810	806.0–821.0	851.0–866.0	dynamic
GSM-850	850	824.0–849.0	869.0–894.0	128–251
P-GSM-900	900	890.2–914.8	935.2–959.8	1–124
E-GSM-900	900	880.0–914.8	925.2–959.8	975–1023, 0-124
R-GSM-900	900	876.0–914.8	921.0–959.8	955–1023, 0-124
T-GSM-900	900	870.4–876.0	915.4–921.0	dynamic
DCS-1800	1800	1710.2–1784.8	1805.2–1879.8	512–885
PCS-1900	1900	1850.0–1910.0	1930.0–1990.0	512–810

1.9 Signal strength:

In telecommunications, particularly in radio, signal strength refers to the magnitude of the electric field at a reference point that is a significant distance from the transmitting antenna. It may also be referred to as received signal level or field strength. Typically, it is expressed in voltage per length or signal power received by a reference antenna. High-powered transmissions, such as those used in broadcasting, are expressed in dB-millivolts per metre (dBmV/m). For very low-power systems, such as mobile phones, signal strength is usually expressed in dB-microvolts per metre (dBμV/m) or in decibels above a reference level of one milliwatt (dBm). In broadcasting terminology, 1 mV/m is 1000 µV/m or 60 dBµ (often written dBu)

1.9.1 Bandwidth:

Bandwidth has several related meanings:

- Bandwidth (signal processing) or analog bandwidth, frequency bandwidth or radio bandwidth: a measure of the width of a range of frequencies, measured in hertz
- Bandwidth (computing) or digital bandwidth: a rate of data transfer, bit rate or throughput, measured in bits per second (bps)
- Spectral line width the width of an atomic or molecular spectral line, measured in hertz

CHAPTER 2

MICROWAVE TRANSMISSION LINE

2.1 Introduction:

At audio frequencies when two pieces of apparatus say a generator and a load are connected together by a pair of short leads, one expects equal input and output current and when the frequencies belong to RF spectrum, neither of these equalities of current and voltage hold .The input and output voltages differing in phase and magnitude. In the long transmission line an equivalent circuit containing resistance, inductance and capacitance is drawn up also the behavior of the transmission line varies when the electrical signals are applied may be predicted. Besides being employed to transmit energy, these are also used as resonant circuit at very high frequencies, as measuring device at high frequencies and as aids to realize impedance matching.

2.2 Transmission Line:

The two ends of a microwave communication system are very similar to each other with both consisting of: one or more antennas; a transmitter and receiver (commonly known as a “transceiver”) and something to connect these two together a “Transmission Line or feeder”.

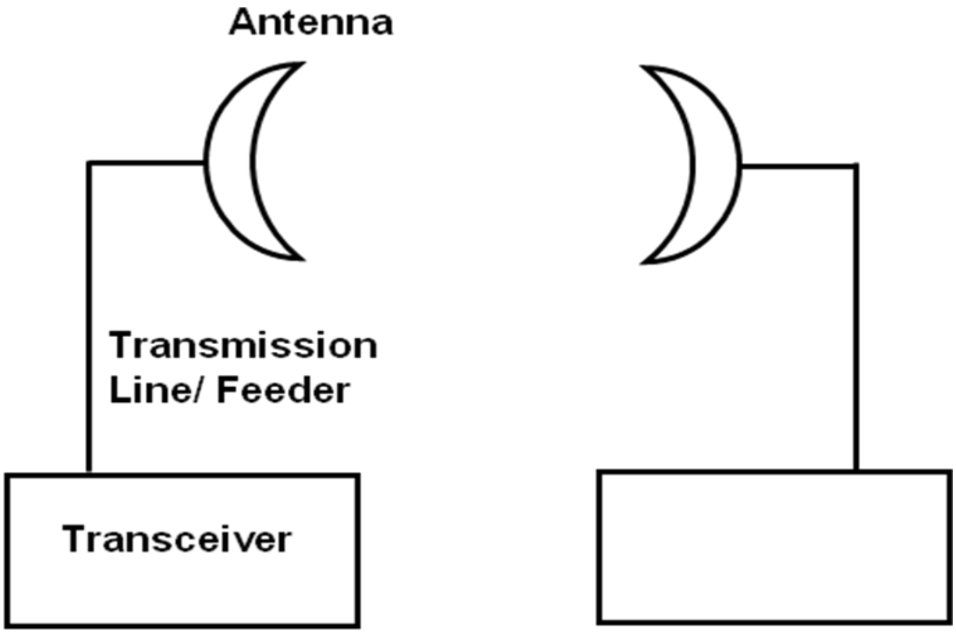


Fig. 2.1 Transmission Line

2.3 Basic Principles of Transmission lines:

Transmission lines are a means to convey electrical signals or power between two points separated by appreciably in distance. At audio frequencies the two pieces of apparatus, say a generator and a load are connected together by a pair of short leads , one expects equal input and equal output currents. Furthermore because of negligible lead resistance the input and output voltages are also expected to be equal.

However, when the lead length is appreciable and when the frequency belongs to R.F spectrum it's never possible to maintain the equality of current and voltage. The input and output voltages vary not only in magnitude but also in phase as well. On such long transmission lines can be treated as an equivalent circuit containing resistance inductance and capacitance and the behavior of the transmission line can be predicted.

2.4 Distributed parameters:

An equivalent circuit of transmission line can be developed by considering a pair of straight wires of equal size and this line is known as the parallel wire line. Since the wires are uniform in size the resistance of the conducting material is considered to be uniformly distributed along their lengths.

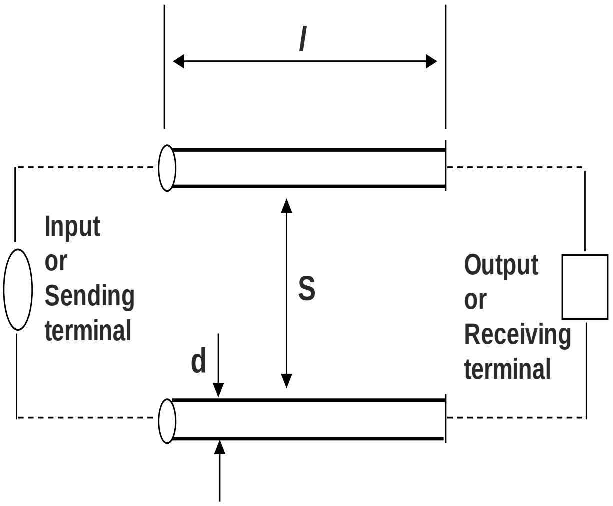


Fig.2.2 Sending and Receiving Terminal

- At radio frequencies, appreciable radiation of energy may take place from the transmission lines possibility of radiation from a .The parallel wire line

- prevented by keeping the separation between the two wires as low as 1/10th of a wavelength.

2.5 Types of Transmission Lines:

A transmission line transmits energy (electric power, acoustic waves or electromagnetic waves) from one point to another as efficiently as possible with minimum energy loss. Energy can be directed through a regular electric wire but with enormous losses. A transmission line is a specialized device designed to transfer energy from a sender (transmitter) to a receiver (antenna) with the least amount of energy loss. Energy loss during transmission depends on the electrical and physical properties of the transmission line, such as resistance and impedance.

2.5.1 Open Wire Line:

An open wire transmission line is made up of two parallel wires. Non-conductive spacers are used between the wires to separate and support them. The distance between the conducting wires is anywhere between 2 to 6 inches. The advantage of the open wire line is its simplicity in construction. The major disadvantage of the open wire line pair is its high energy loss. Since the wires are not shielded, energy loss via radiation is immense. Additionally, the wire pair is capable of picking up random signals, resulting in interference (crosstalk). The open wire transmission line pair is typically used to transmit acoustic waves for telephone applications.

2.5.2 Twisted Pair Line:

A twisted pair transmission line is formed when two individual insulated wire conductors are twisted around one other. The twisting cancels out all electromagnetic interference from neighboring sources, such as crosstalk between nearby wire pairs and radiation generated from a pair of unshielded twisted pair (UTP) transmission lines. Twisted pair lines are shielded to prevent energy loss and external interference. The shielding offered is typically metallic. The advantages of a twisted pair transmission line are its size, flexibility and cost. A pair of twisted transmission lines is less expensive than other types of cables. The disadvantages of a twisted pair cable include stringent installation requirements. This type is not effective during transmission of video data for it is known to cause delays and color defects. The various types of twisted pair cables include loaded twisted pair, unloaded twisted pair, bonded twisted pair and twisted ribbon cables.

2.5.3 Unshielded Twisted Pair:

An unshielded twisted transmission line pair consists of two copper wires that are individually insulated. The insulation is provided by a polyvinyl chloride coating. The wires are twisted more than two times around each other to further reduce external interference and crosstalk. The bandwidth of an unshielded twisted pair is increased by the number of twists per segment and the way in which the wires have been twisted. An unshielded twisted pair transmission line is used for telephonic applications and to connect computer networks. Its major advantage is its flexibility and installation ease. Its major disadvantages include increased external interference and energy loss.

2.6 Primary Constants of TL:

Resistance (R) is defined as a loop resistance per unit length of the line (ohm/km). Inductance (L) is defined as a loop inductance per unit length of the line (henries/km). (G) is define as a shunt conductance between two conductors per unit length of the line (Mhos/km). Capacitance (C) is define as shunt capacitance between two conductors per unit length of the line (farad/km).

CHAPTER 3

ANTENNA

3.1 Introduction:

An antenna (or aerial) is a transducer that transmits or receives electromagnetic waves. In other words, antennas convert electromagnetic radiation into electric current, or vice versa. They are used to transmit and receive electromagnetic radiation of radio frequency, that is, radio waves, and are a necessary part of all radio equipment. Antennas are used in systems such as radio and television broadcasting, point-to-point radio communication, wireless LAN, cell phones, radar, and spacecraft communication. Antennas are most commonly employed in air or outer space, but can also be operated under water or even through soil and rock at certain frequencies for short distances.

Physically, an antenna is an arrangement of one or more conductors, usually called elements in this context. In transmission, an alternating current is created in the elements by applying a voltage at the antenna terminals, causing the elements to radiate an electromagnetic field. In reception, the inverse occurs: an electromagnetic field from another source induces an alternating current in the elements and a corresponding voltage at the antenna's terminals. Some receiving antennas (such as parabolic and horn types) incorporate shaped reflective surfaces to collect the radio waves striking them and direct or focus them onto the actual conductive elements.

3.2 Parameters:

There are several critical parameters affecting an antenna's performance that can be adjusted during the design process. These are resonant frequency, impedance, gain, aperture or radiation pattern, polarization, efficiency and bandwidth. Transmit antennas may also have a maximum power rating, and receive antennas differ in their noise rejection properties. All of these parameters can be measured through various means.

Figure:3.1 Real antenna picture.

3.2.1 Resonant frequency:

Many types of antenna are tuned to work at one particular frequency, and are effective only over a range of frequencies centered on this frequency, called the resonant frequency. These are called resonant antennas. The antenna acts as an electrical resonator. When driven at its resonant frequency, large standing waves of voltage and current are excited in the antenna elements. These large currents and voltages radiate intense electromagnetic waves, so the power radiated by the antenna is maximum at the resonant frequency.

3.2.2 Antenna Gain:

Gain is a parameter which measures the degree of directivity of the antenna's radiation pattern. An antenna with a low gain emits radiation with about the same power in all directions, whereas a high-gain antenna will preferentially radiate in particular directions. Specifically, the antenna gain, directive gain, or power gain of an antenna is defined as the ratio of the intensity (power per unit surface) radiated by the antenna in the direction of its maximum output, at an arbitrary distance, divided by the intensity radiated at the same distance by a hypothetical isotropic antenna.

The gain of an antenna is a passive phenomenon - power is not added by the antenna, but simply redistributed to provide more radiated power in a certain direction than would be transmitted by an isotropic antenna. An antenna designer must take into account the application for the antenna when determining the gain. High-gain antennas have the advantage of longer range and better signal quality, but must be aimed carefully in a particular direction. Low-gain antennas have shorter range, but the orientation of the antenna is relatively inconsequential. For example, a dish antenna on a spacecraft is a high-gain device that must be pointed at the planet to be effective, whereas a typical Wi-Fi antenna in a laptop computer is low-gain, and as long as the base station is within range, the antenna can be in any orientation in space. It makes sense to improve horizontal range at the expense of reception above or below the antenna. Thus most antennas labelled "omnidirectional" really have some gain.[6]

3.2.3 Radiation pattern:

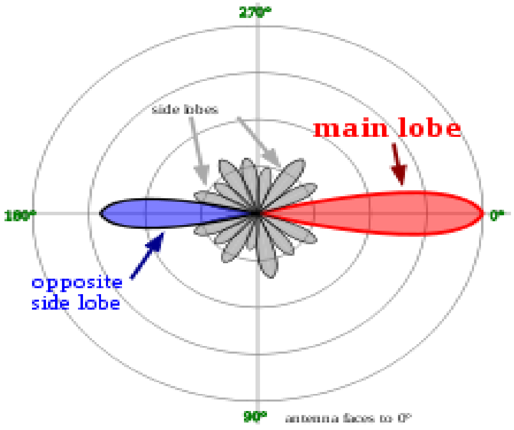


Fig. 3.2 Radiation pattern

polar plots of the horizontal cross sections of a (virtual) Yagi-Uda-antenna. Outline connects points with 3db field power compared to an ISO emitter.

The radiation pattern of an antenna is the geometric pattern of the relative field strengths of the field emitted by the antenna. For the ideal isotropic antenna, this would be a sphere. For a typical dipole, this would be a toroid. The radiation pattern of an antenna is typically represented by a three dimensional graph, or polar plots of the horizontal and vertical cross sections.

The radio waves emitted by different parts of an antenna typically interfere, causing maxima of radiation at some angles where the radio waves arrive in phase, and zero radiation at other angles where the radio waves arrive out of phase. So the radiation of most antennas shows a pattern of maxima or "lobes" at various angles. In a directional antenna designed to project radio waves in a particular direction, the lobe in that direction is larger than the others and is called the "main lobe". The other lobes represent unwanted radiation and are called "side lobes". The axis through the main lobe is called the "principle axis" or "bore sight axis".

3.2.4 Impedance:

As an electro-magnetic wave travels through the different parts of the antenna system (radio, feed line, antenna, free space) it may encounter differences in impedance (E/H, V/I, etc.). At each interface, depending on the impedance match, some fraction of the wave's energy will reflect back to the source, forming a standing wave in the feed line. The ratio of maximum power to minimum power in the wave can be measured and is called the standing wave ratio (SWR**).** A SWR of 1:1 is ideal. A SWR of 1.5:1 is considered to be marginally acceptable in low power applications where power loss is more critical, although an SWR as high as 6:1 may still be usable with the right equipment. Minimizing impedance differences at each interface (impedance matching) will reduce SWR and maximize power transfer through each part of the antenna system.

3.2.5 Efficiency:

Efficiency is the ratio of power actually radiated to the power put into the antenna terminals. A dummy load may have an SWR of 1:1 but an efficiency of 0, as it absorbs all power and radiates heat but very little RF energy, showing that SWR alone is not an effective measure of an antenna's efficiency. Radiation in an antenna is caused by radiation resistance which can only be measured as part of total resistance including loss resistance. Loss resistance usually results in heat generation rather than radiation, and reduces efficiency. Mathematically, efficiency is calculated as radiation resistance divided by total resistance.

3.2.6 Gain

The directive qualities of an antenna are measured by a dimensionless parameter called its gain, which is the ratio of the power received by the antenna from a source along its beam axis to the power received by a hypothetical isotropic antenna. The gain of a parabolic antenna is: [6]

$$G = \frac{4\pi A}{\lambda^2} e_A = \frac{\pi^2 d^2}{\lambda^2} e_A$$

where:

- A is the area of the antenna aperture, that is, the mouth of the parabolic reflector
- d is the diameter of the parabolic reflector
- λ is the wavelength of the radio waves.
- e_A is a dimensionless parameter called the aperture efficiency. The aperture efficiency of typical parabolic antennas is 0.55 to 0.60.

3.2.7 Beamwidth:

The angular width of the beam radiated by high-gain antennas is measured by the half-power beam width (HPBW), which is the angular separation between the points on the antenna radiation pattern at which the power drops to one-half (-3 dB) its maximum value. For parabolic antennas, the HPBW θ is given by:

$$\theta = k\lambda/d$$

where k is a factor which depends on the shape of the reflector and the feed illumination pattern. For a "typical" parabolic antenna k = 70 when θ is in degrees.

For the 2 meter satellite dish at left operating on C band (4 GHz), this formula gives a beamwidth of about 2.6°. For the Arecibo antenna at 2.4 GHz the beamwidth is 0.028°. It can be seen that parabolic antennas can produce very narrow beams, and aiming them can be a problem.

It can be seen there is an inverse relation between gain and beam width. By combining the beamwidth equation with the gain equation, the relation is:

$$G = \left(\frac{\pi k}{\theta}\right)^2 \epsilon_A$$

3.2.8 Bandwidth:

The bandwidth of an antenna is the range of frequencies over which it is effective, usually centered on the resonant frequency. The bandwidth of an antenna may be increased by several techniques, including using thicker wires, replacing wires with cages to simulate a thicker wire, tapering antenna components (like in a feed horn), and combining multiple antennas into a single assembly (array) and allowing the natural impedance of suitable inductive RF filter traps to select the correct antenna. All these attempts to increase bandwidth by adding capacitance to the surface area have a detrimental effect on efficiency by reducing the Q factor. They also have an adverse effect on the rejection of unwanted harmonics, on both received and transmitted signal frequencies. Small antennas are usually preferred for convenience, but there is a fundamental limit relating bandwidth, size and efficiency.

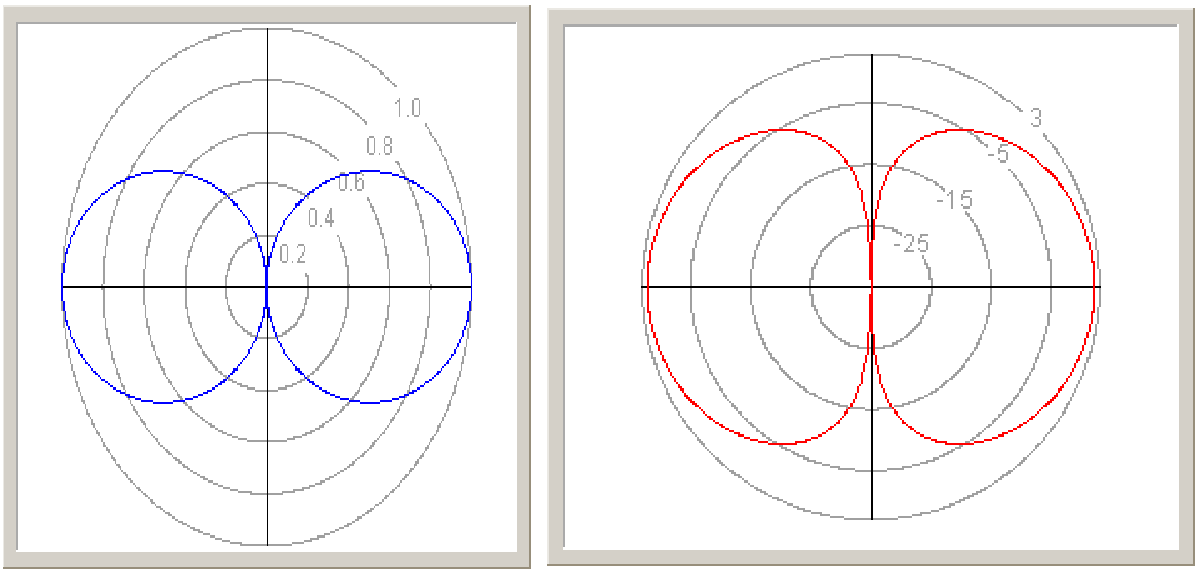
3.3 Polarization:

The polarization of an antenna is the orientation of the electric field (E-plane) of the radio wave with respect to the Earth's surface and is determined by the physical structure of the antenna and by its orientation. It has nothing in common with antenna directionality terms: "horizontal", "vertical" and "circular". Thus, a simple straight wire antenna will have one polarization when mounted vertically, and a different polarization when mounted horizontally. "Electromagnetic wave polarization filters" are structures which can be employed to act directly on the electromagnetic wave to filter out wave energy of an undesired polarization and to pass wave energy of a desired polarization.

Reflections generally affect polarization. For radio waves the most important reflector is the ionosphere - signals which reflect from it will have their polarization changed unpredictably. For signals which are reflected by the ionosphere, polarization cannot be relied upon. For line-of-sight communications for which polarization can be relied upon, it can make a large difference in signal quality to have the transmitter and receiver using the same polarization; many tens of dB difference are commonly seen and this is more than enough to make the difference between reasonable communication and a broken link

Radiation pattern and gain

Dipoles have an omnidirectional radiation pattern, shaped like a toroid (doughnut) symmetrical about the axis of the dipole. The radiation is maximum at right angles to the dipole, dropping off to zero on the antenna's axis. The theoretical maximum gain of a Hertzian dipole is 10 log 1.5 or 1.76 dBi. The maximum theoretical gain of a λ/2-dipole is 10 log 1.64 or 2.15 dBi.



Radiation pattern of a half-wave dipole antenna. The scale is linear.

Gain of a half-wave dipole (same as left). The scale is in dBi (decibels over isotropic).

Fig.3.3 Radiation pattern and Gain of a half-wave dipole antenna

3.4 Transmission and reception:

All of the antenna parameters are expressed in terms of a transmission antenna, but are identically applicable to a receiving antenna, due to reciprocity. Impedance, however, is not applied in an obvious way; for impedance, the impedance at the load (where the power is consumed) is most critical. For a transmitting antenna, this is the antenna itself. For a receiving antenna, this is at the (radio) receiver rather than at the antenna. Tuning is done by adjusting the length of an electrically long linear antenna to alter the electrical resonance of the antenna.

Antenna tuning is done by adjusting an inductance or capacitance combined with the active antenna (but distinct and separate from the active antenna). The inductance or capacitance provides the reactance which combines with the inherent reactance of the active antenna to establish a resonance in a circuit including the active antenna. The established resonance being at a frequency other than the natural electrical resonant frequency of the active antenna. Adjustment of the inductance or capacitance changes this resonance.

3.4.1 Effect of ground:

Antennas are typically used in an environment where other objects are present that may have an effect on their performance. Height above ground has a very significant effect on the radiation pattern of some antenna types. At frequencies used in antennas, the ground behaves mainly as a dielectric. The conductivity of ground at these frequencies is negligible. When an electromagnetic wave arrives at the surface of an object, two waves are created: one enters the dielectric and the other is reflected. If the object is a conductor, the transmitted wave is negligible and the reflected wave has almost the same amplitude as the incident one. When the object is a dielectric, the fraction reflected depends (among others things) on the angle of incidence. When the angle of incidence is small (that is, the wave arrives almost perpendicularly) most of the energy traverses the surface and very little is reflected. When the angle of incidence is near 90° (grazing incidence) almost all the wave is reflected.

Most of the electromagnetic waves emitted by an antenna to the ground below the antenna at moderate (say < 60°) angles of incidence enter the earth and are absorbed (lost). But waves emitted to the ground at grazing angles, far from the antenna, are almost totally reflected. At grazing angles, the ground behaves as a mirror. Quality of reflection depends on the nature of the surface. When the irregularities of the surface are smaller than the wavelength reflection is good.

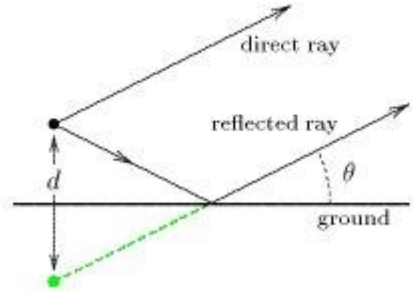


Fig.3.4 Wave reflection from ground

The wave reflected by earth can be considered as emitted by the image antenna. This means that the receptor "sees" the real antenna and, under the ground, the image of the antenna reflected by the ground . If the ground has irregularities, the image will appear fuzzy. If the receiver is placed at some height above the ground, waves reflected by ground will travel a little longer distance to arrive to the receiver than direct waves. The distance will be the same only if the receiver is close to ground. In the drawing at right, we have drawn the angle θfar bigger than in reality. Distance between the antenna and its image is d. The situation is a bit more complex because the reflection of electromagnetic waves depends on the polarization of the incident wave. As the refractive index of the ground (average value $\simeq 2$) is bigger than the refractive index of the air ($\simeq 1$), the direction of the component of the electric field parallel to the ground inverses at the reflection. This is equivalent to a phase shift of π radians or 180°. The vertical component of the electric field reflects without changing direction. This sign inversion of the parallel component and the non-inversion of the perpendicular component would also happen if the ground were a good electrical conductor

.

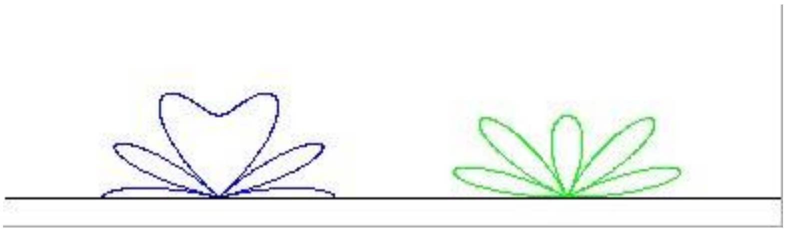


Fig. 3.5 Radiation patterns of antennas and their images reflected by the ground.

Radiation patterns of antennas and their images reflected by the ground. At left the polarization is vertical and there is always a maximum for $\theta=0$. If the polarization is horizontal as at right, there is always a zero for $\theta=0$.

For emitting and receiving antenna situated near the ground (in a building or on a mast) far from each other, distances traveled by direct and reflected rays are nearly the same. There is no induced phase shift. If the emission is polarized vertically the two fields (direct and reflected) add and there is maximum of received signal. If the emission is polarized horizontally the two signals subtracts and the received signal is minimum. This is depicted in the image at right. In the case of vertical polarization, there is always a maximum at earth level (left pattern). For horizontal polarization, there is always a minimum at earth level. Note that in these drawings the ground is considered as a perfect mirror, even for low angles of incidence. In these drawings the distance between the antenna and its image is just a few wavelengths. For greater distances, the number of lobes increases.

address radio emissions have Note that the situation is different–and more complex–if reflections in the ionosphere occur. This happens over very long distances (thousands of kilometers). There is not a direct ray but several reflected rays that add with different phase shifts.

This is the reason why almost all public vertical polarization. As public users are near ground, horizontal polarized emissions would be poorly received. Observe household and automobile radio receivers. They all have vertical antennas or horizontal ferrite antennas for vertical polarized emissions. In cases where the receiving antenna must work in any position, as in mobile phones, the emitter and receivers in base stations use circular polarized electromagnetic waves.

Classical (analog) television emissions are an exception. They are almost always horizontally polarized, because the presence of buildings makes it unlikely that a good emitter antenna image will appear. However, these same buildings reflect the electromagnetic waves and can create ghost images. Using horizontal polarization, reflections are attenuated because of the low reflection of electromagnetic waves whose magnetic field is parallel to the dielectric surface near the Brewster's angle. Vertically polarized analog television has been used in some rural areas. In digital terrestrial television reflections are less obtrusive, due to the inherent robustness of digital signalling and built-in error correction

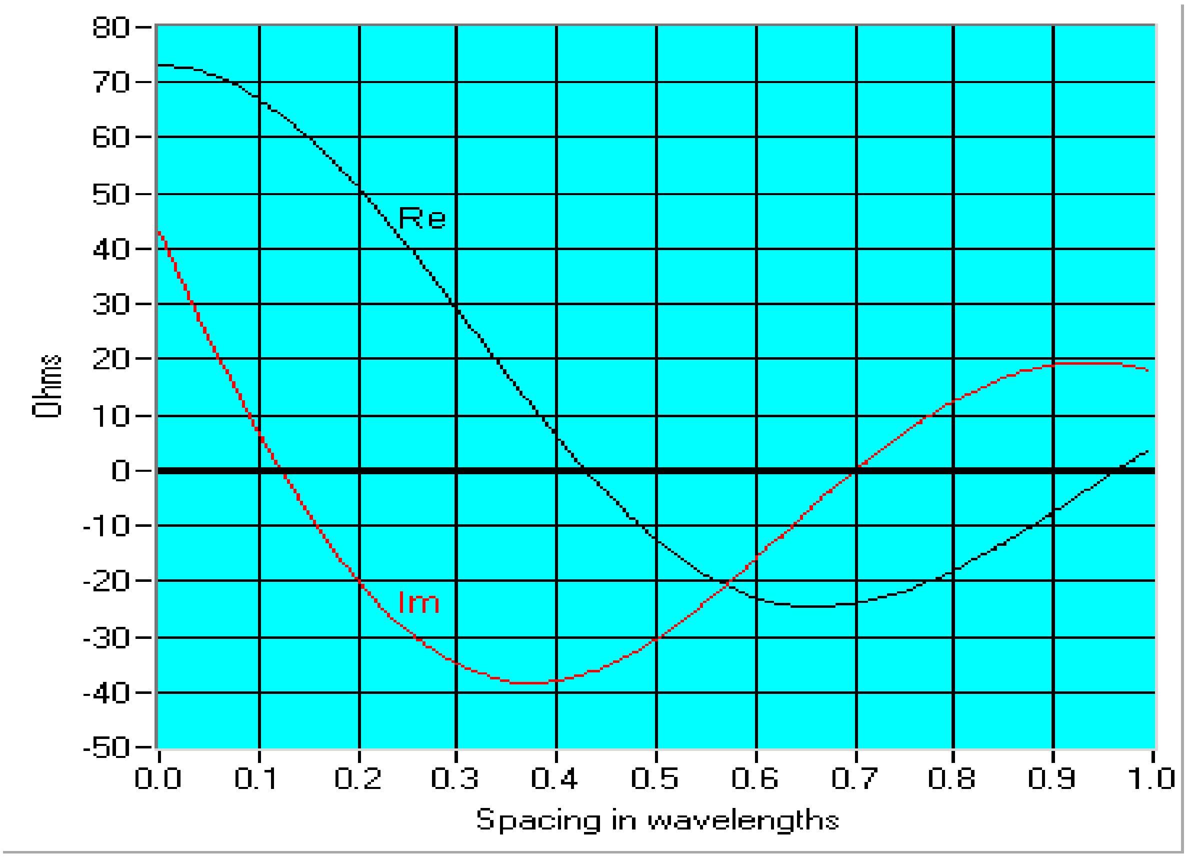


Fig.3.6 Mutual impedance and interaction between antennas

Mutual impedance between parallel $\frac{\lambda}{2}$dipoles not staggered. Curves Re and Im are the resistive and reactive parts of the impedance.

Current circulating in any antenna induces currents in all others. One can postulate a mutual impedance Z_{12}between two antennas that has the same significance as the $j\omega M$in ordinary coupled inductors. The mutual impedance Z_{12}between two antennas is defined as:

$$Z_{12} = \frac{v_2}{i_1}$$

where $i_1$is the current flowing in antenna 1 and $v_2$is the voltage that would have to be applied to antenna 2–with antenna 1 removed–to produce the current in the antenna 2 that was produced by antenna 1.

From this definition, the currents and voltages applied in a set of coupled antennas are:

$$\begin{array}{ccccccccc}
v_1 & = & i_1 Z_{11} & + & i_2 Z_{12} & + & \cdots & + & i_n Z_{1n} \\
v_2 & = & i_1 Z_{21} & + & i_2 Z_{22} & + & \cdots & + & i_n Z_{2n} \\
\vdots & & \vdots & & \vdots & & & & \vdots \\
v_n & = & i_1 Z_{n1} & + & i_2 Z_{n2} & + & \cdots & + & i_n Z_{nn}
\end{array}$$

where:

- v_i is the voltage applied to the antenna i
- Z_{ii} is the impedance of antenna i
- Z_{ij} is the mutual impedance between antennas i and j

Note that, as is the case for mutual inductances,

$$Z_{ij} = Z_{ji}$$

This is a consequence of Lorentz reciprocity. If some of the elements are not fed (there is a short circuit instead a feeder cable), as is the case in television antennas (Yagi-Uda antennas), the corresponding v_i are zero. Those elements are called parasitic elements. Parasitic elements are unpowered elements that either reflect or absorb and reradiate RF energy.

In some geometrical settings, the mutual impedance between antennas can be zero. This is the case for crossed dipoles used in circular polarization antennas.

3.5 Types of Antenna:

3.5.1 Parabolic antenna:

A parabolic antenna is an antenna that uses a parabolic reflector, a surface with the cross-sectional shape of a parabola, to direct the radio waves. The most common form is shaped like a dish and is popularly called a dish antenna or parabolic dish. The main advantage of a parabolic antenna is that it is highly directive; it functions analogously to a searchlight or flashlight reflector to direct the radio waves in a narrow beam, or receive radio waves from one particular direction only. Parabolic antennas have some of the highest gains, that is they can produce the narrowest beam width angles, of any antenna type. They are used as high-gain antennas for point-to-point radio, television and data communications, and also for radiolocation (radar), on the UHF and microwave (SHF) parts of the electromagnetic spectrum. The relatively short wavelength of electromagnetic radiation at these frequencies allows reasonably sized reflectors to exhibit the desired highly directional response.[3]

3.5.2 Dipole antenna:

A dipole antenna is a radio antenna that can be made of a simple wire, with a center-fed driven element. It consists of two metal conductors of rod or wire, oriented parallel and collinear with each other (in line with each other), with a small space between them. The radio frequency voltage is applied to the antenna at the center, between the two conductors. These antennas are the simplest practical antennas from a theoretical point of view. They are used alone as antennas, notably in traditional "rabbit ears" television antennas, and as the driven element in many other types of antennas, such as the Yagi. Dipole antennas were invented by German physicist Heinrich Hertz around 1886 in his pioneering experiments with radio waves.

3.5.3 Dipole characteristics:

Dipoles that are much smaller than the wavelength of the signal are called Hertzian, short, or infinitesimal dipoles. These have a very low radiation resistance and a high reactance, making them inefficient, but they are often the only available antennas at very long wavelengths. Dipoles whose length is half the wavelength of the signal are called half-wave dipoles, and are more efficient. In general radio engineering, the term dipole usually means a half-wave dipole (center-fed).

A half-wave dipole is cut to length l for frequency f MHz according to the formula $l = \frac{143}{f}$ where l is in metres or $l = \frac{468}{f}$ where l is in feet. This is because the impedance of the dipole is resistive pure at about this length. The length of the dipole antenna is about 95% of half a wavelength at the speed of light in free space.

The magic numbers above are derived from a one Hz wavelength which is the distance that light radio travels in one second. Speed of light in vacuum is 299,792,458 m/s, which is divided by 1 million to account for MHz rather than Hz, which is then divided by 2 for a half-wave dipole antenna. A fudge factor of approximately 0.95 is multiplied to account for the damping due to radiation, which results in the magic number of 143 m·MHz or 468 ft·MHz.

3.5.4 Directional antenna:

A directional antenna or beam antenna is an antenna which radiates greater power in one or more directions allowing for increased performance on transmit and receive and reduced interference from unwanted sources. Directional antennas like yagi antennas provide increased performance over dipole antennas when a greater concentration of radiation in a certain direction is desired.

3.5.5 Omni directional antenna:

An omnidirectional antenna is an antenna which radiates power uniformly in one plane, with the radiated power decreasing with elevation angle above or below the plane, dropping to zero on the antenna's axis. This radiation pattern is often described as "donut shaped". Omnidirectional antennas oriented vertically are widely used for nondirectional antennas on the surface of the Earth because they radiate equally in all horizontal directions, while the power radiated drops off with elevation angle so little radio energy is aimed into the sky or down toward the earth and wasted. Omnidirectional antennas are widely used for radio broadcasting antennas, and in mobile devices that use radio such as cell phones, FM radios, walkie-talkies, Wifi, cordless phones, GPS as well as for base stations that communicate with mobile radios, such as police and taxi dispatchers and aircraf

3.6 Antenna aperture:

As a receiver, antenna aperture can be visualized as the area of a circle constructed broadside to incoming radiation where all radiation passing within the circle is delivered by the antenna to a matched load. (Note that transmitting and receiving are reciprocal, so the aperture is the same for both.) Thus incoming power density (watts per square metre) x aperture (square metres)= available power from antenna (watts). Antenna gain is directly proportional to aperture. An isotropic antenna has an aperture of

$$\frac{\lambda^2}{4\pi}$$

where λ is the wavelength. An antenna with a gain of G has an aperture of

$$\frac{G\lambda^2}{4\pi}.$$

Generally, antenna gain is increased by directing radiation in a single direction, while necessarily reducing it in all other directions since power cannot be created by the antenna. Thus a larger aperture produces a higher gain and narrower beamwidth.

Large parabolic antennas, many wavelengths across, have an aperture nearly equal to their physical area.

3.7 Antenna effective area:

In telecommunications, antenna effective area or effective aperture is the functionally equivalent area from which an antenna directed toward the source of the received signal gathers or absorbs the energy of an incident electromagnetic wave. Note 1: Antenna effective area is usually expressed in square meters. Note 2: In the case of parabolic and horn-parabolic antennas, the antenna effective area is about 0.35 to 0.55 of the geometric area of the antenna aperture.

$$A_{\text{eff}} = \frac{P_0}{P}$$

Where P_0 is the power absorbed by the antenna, and P is the power density incident on the antenna per unit area. It is assumed that the antenna is terminated with a matched load to absorb the maximum power

3.8 Feeder line:

Ideally, a half-wave (λ/2) dipole should be fed with a balanced line matching the theoretical 73 ohm impedance of the antenna. A folded dipole uses a 300 ohm balanced feeder line.

Many people have had success in feeding a dipole directly with a coaxial cable feed rather than a ladder-line. However, coax is not symmetrical and thus not a balanced feeder. It is unbalanced, because the outer shield is connected to earth potential at the other end. When a balanced antenna such as a dipole is fed with an unbalanced feeder, common mode currents can cause the coax line to radiate in addition to the antenna itself, and the radiation pattern may be asymmetrically distorted. This can be remedied with the use of a balun.

3.9 Calculation of Antenna parameters in reception:

The gain in any given direction and the impedance at a given frequency are the same when the antenna is used in transmission or in reception. The electric field of an electromagnetic wave induces a small voltage in each small segment in all electric conductors. The induced voltage depends on the electrical field and the conductor length. The voltage depends also on the relative orientation of the segment and the electrical field. Each small voltage induces a current and these currents circulate through a small part of the antenna impedance. The result of all those currents and tensions is far from immediate. However, using the reciprocity theorem, it is possible to prove that the Thévenin equivalent circuit of a receiving antenna is:

$$V_a = \frac{\sqrt{R_a G_a}\,\lambda \cos\psi}{\sqrt{\pi Z_\circ}} E_b$$

- $V_a$is the Thévenin equivalent circuit tension.
- $Z_a$is the Thévenin equivalent circuit impedance and is the same as the antenna impedance.
- $R_a$is the series resistive part of the antenna impedance Z_a.
- $G_a$is the directive gain of the antenna (the same as in emission) in the direction of arrival of electromagnetic waves.
- $\lambda$is the wavelength.
- $E_b$is the magnitude of the electrical field of the incoming electromagnetic wave.
- $\psi$is the angle of misalignment of the electrical field of the incoming wave with the antenna. For a dipole antenna, the maximum induced voltage is obtained

when the electrical field is parallel to the dipole. If this is not the case and they are misaligned by an angle ψ, the induced voltage will be multiplied by $\cos\psi$.

- $Z_\circ=\sqrt{\frac{\mu_\circ}{\varepsilon_\circ}}=376.7303134612\Omega$ is a universal constant called vacuum impedance or impedance of free space.

The equivalent circuit and the formula at right are valid for any type of antenna. It can be as well a dipole antenna, a magnetic loop, a parabolic antenna, or an antenna array.

From this formula, it is easy to prove the following definitions:

Antenna effective length $= \dfrac{\sqrt{R_a G_a}\lambda\cos\psi}{\sqrt{\pi Z_\circ}}$

is the length which, multiplied by the electrical field of the received wave, give the voltage of the Thévenin equivalent antenna circuit.

Maximum available power $= \dfrac{G_a\lambda^2}{4\pi Z_\circ}E_b^2$

is the maximum power that an antenna can extract from the incoming electromagnetic wave.

Cross section or effective capture surface $= \dfrac{G_a}{4\pi}\lambda^2$

is the surface which multiplied by the power per unit surface of the incoming wave, gives the maximum available power.

The maximum power that an antenna can extract from the electromagnetic field depends only on the gain of the antenna and the squared wave length λ. It does not depend on the antenna dimensions. Using the equivalent circuit, it can be shown that the maximum power is absorbed by the antenna when it is terminated with a load matched to the antenna input impedance. This also implies that under matched conditions, the amount of power re-radiated by the receiving antenna is equal to that absorbed.

CHAPTER O4

CONSIDERABLE PARAMETERS FOR MICROWAVE LINK

4.1 Introduction:

Most installers know that clear line of sight is required between two antennas but there is a lot more to it than that. In this article, the basics of microwave transmission line and its performance analysis will be discussed.

4.2 Fresnel zone:

Fresnel zone *d* is the distance between the transmitter and the receiver; *b* is the radius of the Fresnel zone. In optics and radio communications (indeed, in any situation involving the radiation of waves, which includes electrodynamics, acoustics, and gravitational radiation), a Fresnel zone (pronounced /freɪˈnɛl/ *fray-NELL*), named for physicist Augustin-Jean Fresnel, is one of a (theoretically infinite) number of concentric ellipsoids which define volumes in the radiation pattern of a (usually) circular aperture. [4]

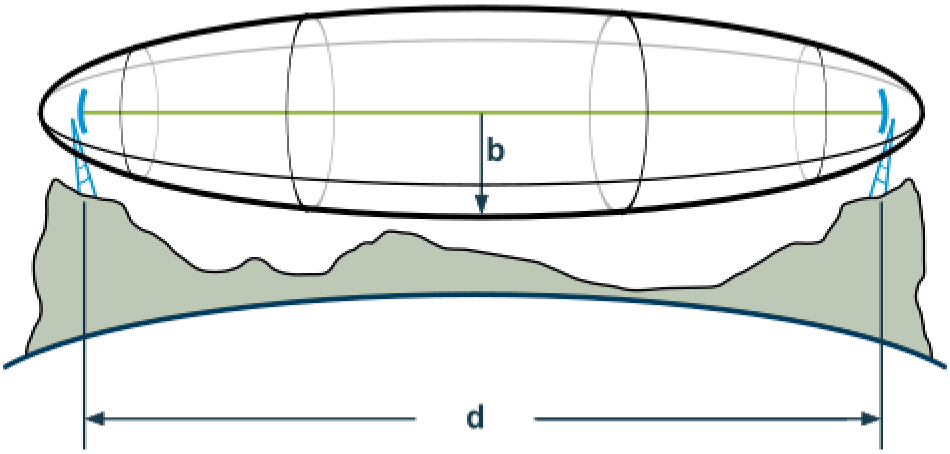


Fig.4.1 Fresnel zones result from diffraction by the circular aperture.

The cross section of the first (innermost) Fresnel zone is circular. Subsequent Fresnel zones are annular (doughnut-shaped) in cross section, and concentric with the first.To maximize receiver strength, one needs to minimize the effect of the out-of-phase signals by removing obstacles from the radio frequency line of sight (RF LoS). The strongest signals are on the direct line between transmitter and receiver and always lie in the first Fresnel zone.

4.2.1 Fresnel zone formula:

$$\text{Path difference: } d3 = \sqrt{d1^2 + r1^2} + \sqrt{d2^2 + r1^2} - d = \frac{\lambda}{2}$$

$$\text{Fresnel radius: } r1 = \sqrt{\lambda \frac{d1 \times d2}{d1 + d2}}$$

4.3 Free-space path loss:

In telecommunication, free-space path loss (FSPL) is the loss in signal strength of an electromagnetic wave that would result from a line-of-sight path through free space (usually air), with no obstacles nearby to cause reflection or diffraction. It does not include factors such as the gain of the antennas used at the transmitter and receiver, nor any loss associated with hardware imperfections. A discussion of these losses may be found in the article on link budget

4.3.1 Free-space path loss formula:

Free-space path loss is proportional to the square of the distance between the transmitter and receiver, and also proportional to the square of the frequency of the radio signal.

The equation for FSPL is

$$\begin{aligned} \mathrm{FSPL} &= \left(\frac{4\pi d}{\lambda}\right)^2 \\ &= \left(\frac{4\pi d f}{c}\right)^2 \end{aligned}$$

where:

- $\lambda$is the signal wavelength (in metres),
- $f$is the signal frequency (in hertz),
- $d$is the distance from the transmitter (in metres),
- $c$is the speed of light in a vacuum, 2.99792458×10^8 metres per second.

This equation is only accurate in the far field where spherical spreading can be assumed; it does not hold close to the transmitter

4.4 Line-of-sight propagation:

Line-of-sight propagation refers to electro-magnetic radiation or acoustic wave propagation. Electromagnetic transmission includes light emissions traveling in a straight line. The rays or waves may be diffracted, refracted, reflected, or absorbed by atmosphere and obstructions with material and generally cannot travel over the horizon or behind obstacles. At low frequencies (below approximately 2 MHz or so) radio signals travel as ground waves, which follow the Earth's curvature due to diffraction with the layers of atmosphere. This enables AM radio signals in low-noise environments to be received well after the transmitting antenna has dropped below the horizon. Additionally, frequencies between approximately 1 and 30 MHz, can be reflected by the F1/F2 Layer, thus giving radio transmissions in this range a potentially global reach (see shortwave radio), again along multiply deflected straight lines

4.5 Effective Isotropic Radiated Power (EIRP):

Effective Isotropic Radiated Power (EIRP) is the output power when a signal is concentrated into a smaller area by the Antenna.

An isotropic radiator radiates power equally in all directions, however a perfect isotropic radiator is only theoretical as even the simplest antennas will concentrate the signal in certain direction(s). E.g. a 1/2 wave dipole has a gain of 2.15 dBi. [7]

The EIRP is calculated using this formula:

EIRP = Effective Isotropic Radiated Power

Pout = transmitter power output (dBm)

Ct = signal loss in cable (dB)

Gt = gain of the antenna (dBi) Pout - Ct + Gt = EIRP

When installing a wireless system with external antenna, your EIRP calculation should not exceed the class license limit. Other wise you must adjust either the transmitter power output, the length of cable and/or the choice of antenna

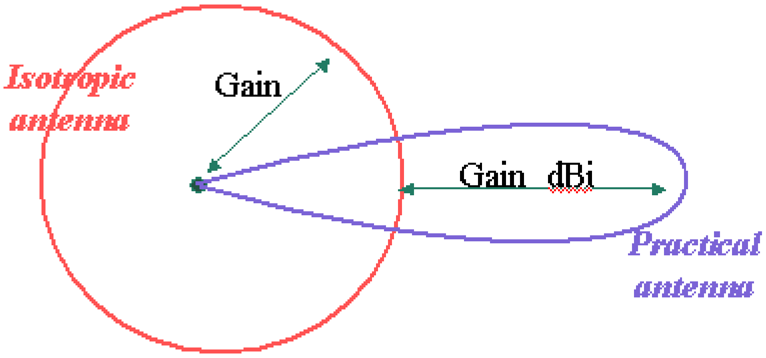


Fig.4.2 Gain of Isotropic and Practical antenna

4.6 Receiver Sensitivity:

The sensitivity of an electronic device, such as a communications system receiver, or detection device, such as a PIN diode, is the minimum magnitude of input signal required to produce a specified output signal having a specified signal-to-noise ratio, or other specified criteria.

Sensitivity is sometimes improperly used as a synonym for responsivity

4.7 Signal to noise ratio:

In analog and digital communications, signal-to-noise ratio, often written S/N or SNR, is a measure of signal strength relative to background noise. The ratio is usually measured in decibels (dB).

If the incoming signal strength in microvolts is V_s, and the noise level, also in microvolts, is V_n, then the signal-to-noise ratio, S/N, in decibels is given by the formula

$S/N = 20 \log_{10}(V_s/V_n)$

If $V_s = V_n$, then $S/N = 0$. In this situation, the signal borders on unreadable, because the noise level severely competes with it. In digital communications, this will probably cause a reduction in data speed because of frequent errors that require the source (transmitting) computer or terminal to resend some packets of data.

Ideally, V_s is greater than V_n, so S/N is positive. As an example, suppose that V_s = 10.0 microvolts and V_n = 1.00 microvolt. Then

$S/N = 20 \log_{10}(10.0) = 20.0$ dB

which results in the signal being clearly readable. If the signal is much weaker but still above the noise -- say 1.30 microvolts -- then

$S/N = 20 \log_{10}(1.30) = 2.28$ dB

which is a marginal situation. There might be some reduction in data speed under these conditions.

If V_s is less than V_n, then S/N is negative. In this type of situation, reliable communication is generally not possible unless steps are taken to increase the signal level and/or decrease the noise level at the destination (receiving) computer or terminal.

4.8 Interference (wave propagation) :

Interference of two circular waves. Absolute value snapshots of the (real-valued, scalar) wave field. Wavelength increasing from top to bottom, distance between wave centers increasing from left to right. The dark regions indicate destructive interference.

In physics, interference is the addition of two or more waves that results in a new wave pattern. Interference usually refers to the interaction of waves that are correlated or coherent with each other, either because they come from the same source or because they have the same or nearly the same frequency. Interference in physics corresponds to what in wireless communications is known as fading, while the term interference has a different meaning in wireless communications.

CHAPTER 05

PERFORMANCE ANALYSIS OF MICROWAVE TRANSMISSION LINE

5.1 Voltage Standing Wave Ratio (VSWR):

Voltage Standing Wave Ratio (VSWR) is the ratio of the maximum voltage to the minimum voltage in the standing wave on a transmission line. Standing waves are the result of reflected RF energy. As the VSWR approaches 1.00:1, the reflections on the line approach zero and maximum power may be transmitted. Reflections occur any place where the impedance of the transmission line changes. Inside a typical base station antenna, the Impedance of the line is changed at many places in order to distribute the RF energy across the aperture. Antenna engineers design matching sections inside the antenna to minimize the overall impedance change (and associated reflections) relative to a 50 ohm reference. Measuring the VSWR of the antenna indicates the how closely the antenna is matched to 50 ohms Impedance and indicates the magnitude of the reflected energy.[8]

5.2 How is VSWR measured?

The VSWR of base station antennas is measured using a device called a network analyzer. The network analyzer is a meter that injects signals into the antenna across a wide frequency band and measures the magnitude of the reflected signals. Calibration standards are used to “calibrate” or “zero” the network analyzer at the end of a test cable. This point becomes the” reference plane” to which the impedance of the antenna under test is compared.

5.3 Finding a proper location to test base station antennas:

When measuring VSWR, a small amount of RF energy is transmitted by the network analyzer and radiated from the antenna under test. Any external objects (particularly metal objects) in the field of view of the antenna will reflect that energy back into the antenna. This reflected signal will add to or subtract from the internal reflections of the antenna as a function of wavelength, causing ripple to be seen in the VSWR measurement. The magnitude of this ripple can be large enough to make a “good” antenna appear “bad.” When base station antennas are tested at the factory, the antenna is placed in front of a wall of RF absorbing material. The RF absorber dissipates the radiated energy from the antenna and prevents reflections outside of the antenna from bouncing back into the measurement.[5]

5.4 Other considerations:

1) Never test base station antennas inside a building (unless you have a wall of RF absorber!)

2) Do not point the antenna at the ground.

3) Avoid parked cars, fences and buildings within the field of view of the antenna.

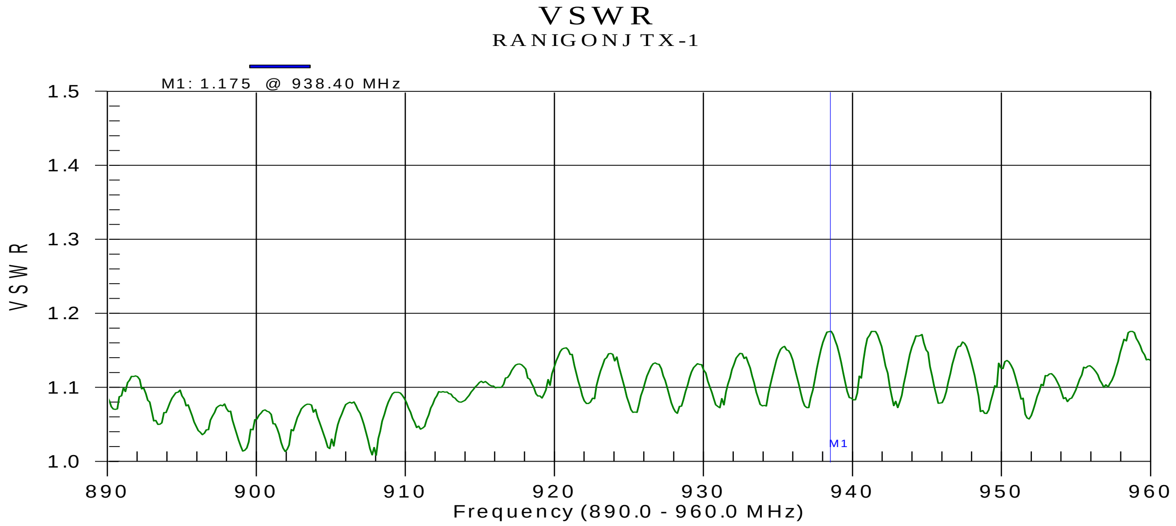
4) Do not put any part of your body in front of the antenna while performing a test. Arms and legs in front of the antenna will cause large reflections!

Equipment Test:

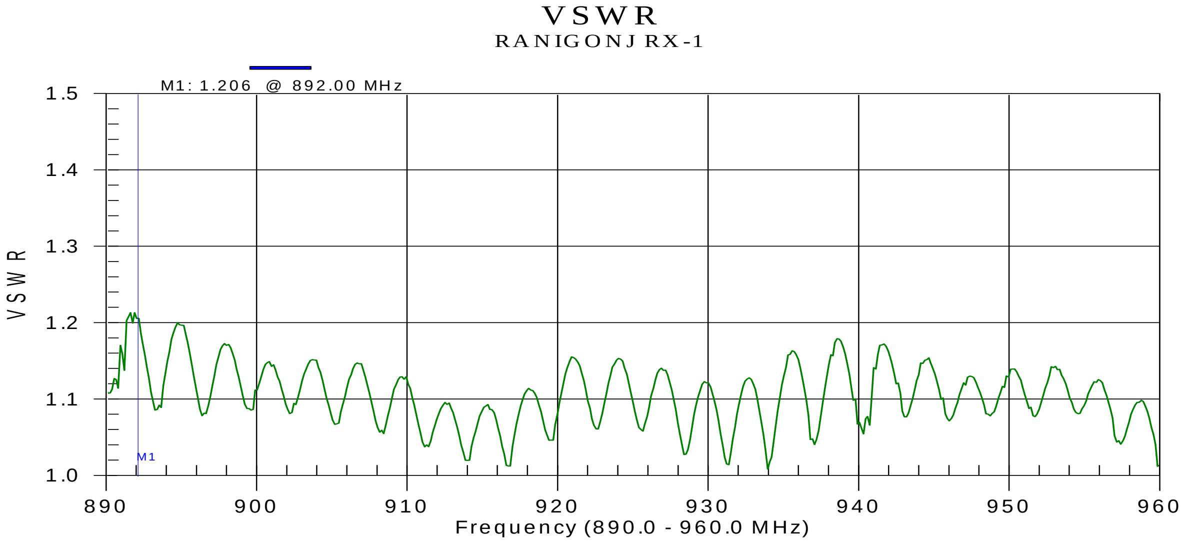
Fig. 5.1 Site Master, Antenna, Jumper Cable and Connector

5.5 Test the antenna:

Attach the calibrated reference plane (test cable) directly to the antenna under test. Make sure the connection is tight. Observe the maximum VSWR in the frequency range of interest on the network analyzer. Compare the value measured to the antenna manufacturer’s specification for that antenna to determine if the antenna is “good” or “bad.”



Resolution: 517 | CAL:ON(COAX) | CW: OFF
Date: 08/23/2010 | Time: 07:00:44
Model: S331D | Serial #: 00814068

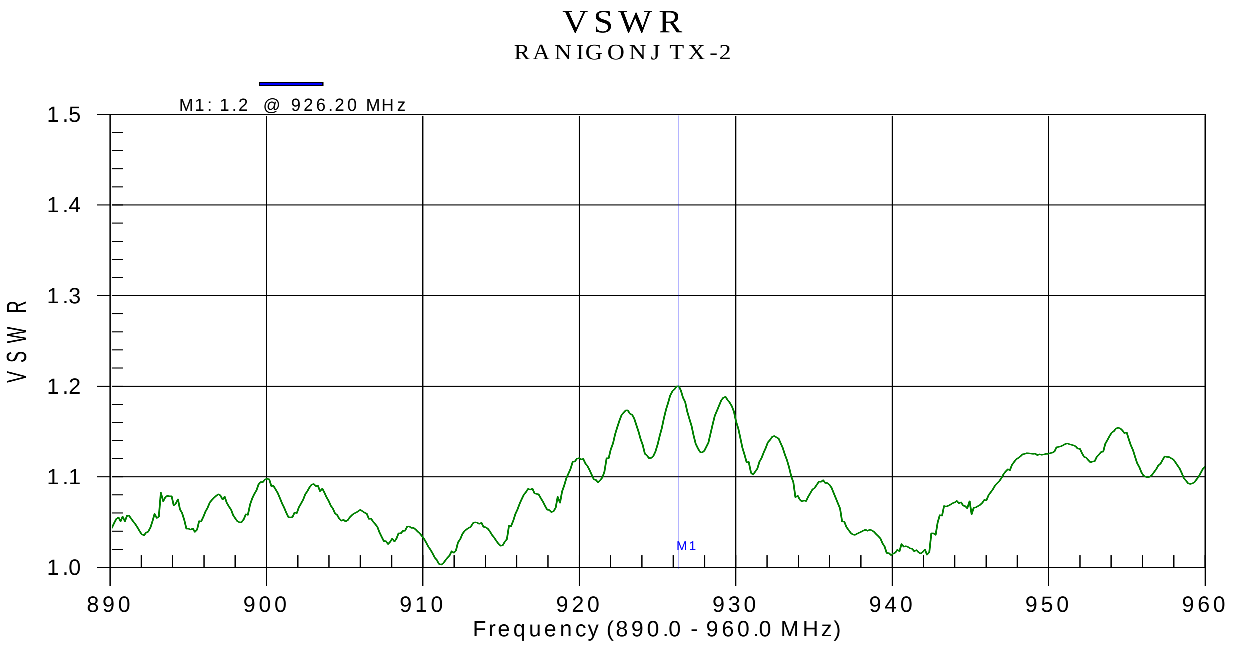


Resolution: 517 | CAL:ON(COAX) | CW: OFF
Date: 08/23/2010 | Time: 07:01:49
Model: S331D | Serial #: 00814068

Fig.5.2 Ranigonj VSWR Tx1 and Rx1

Site Name: Rani Gonj
Atowari, Panchager

Cell 1	VSWR	Frequency Range (890-960 MHz)
Tx 1	1.176	938 MHz
Rx 1	1.206	892 MHz

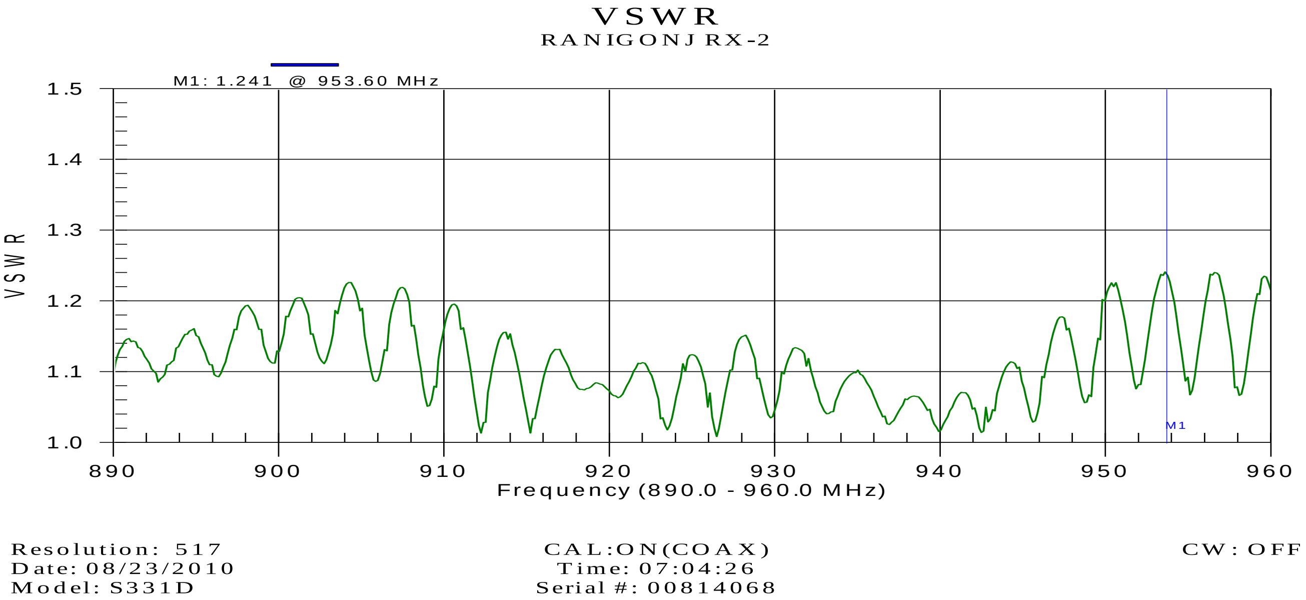


Resolution: 517
Date: 08/23/2010
Model: S331D

CAL:ON(COAX)
Time: 07:03:17
Serial #: 00814068

CW: OFF

Fig. 5.3:Ranigonj VSWR Tx2



VSWR

RANIGONJ RX-2

M1: 1.241 @ 953.60 MHz

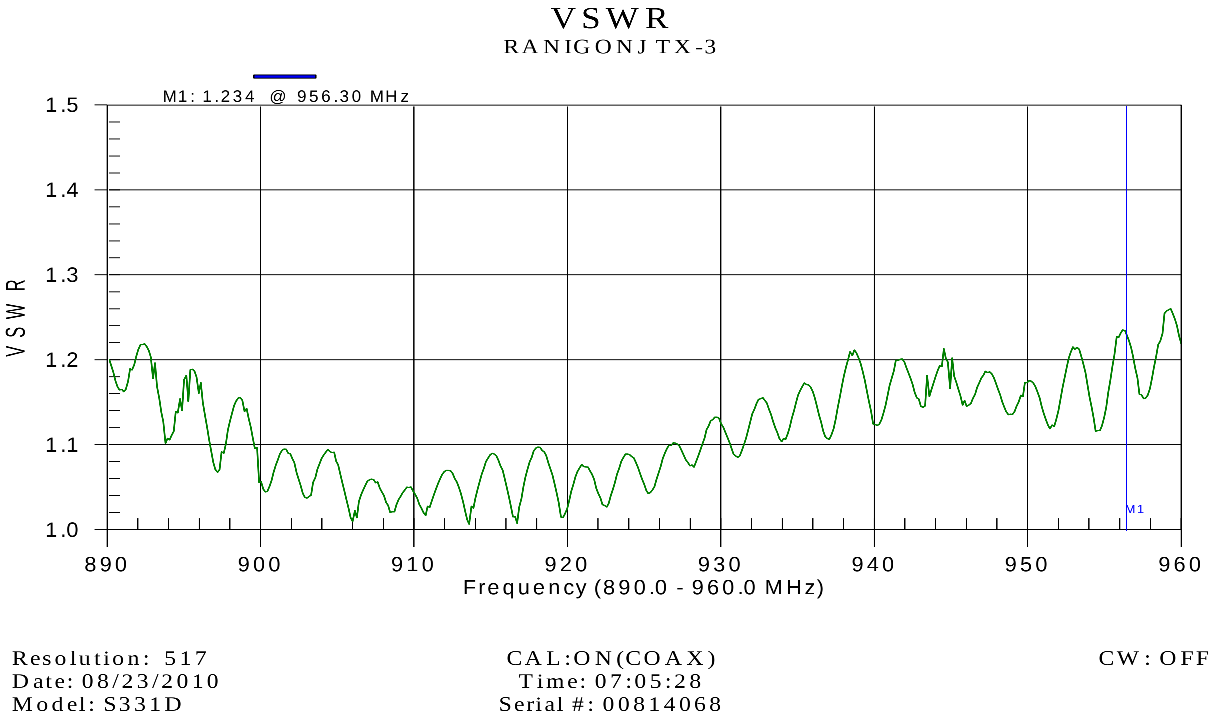
Resolution: 517
Date: 08/23/2010
Model: S331D

CAL:ON(COAX)
Time: 07:04:26
Serial #: 00814068

CW: OFF

Site Name: Rani Gonj
Atowari, Panchager

Cell 2	VSWR	Frequency Range (890-960 MHz)
Tx 2	1.20	926 MHz
Rx 2	1.214	953 MHz



VSWR

RANIGONJ TX-3

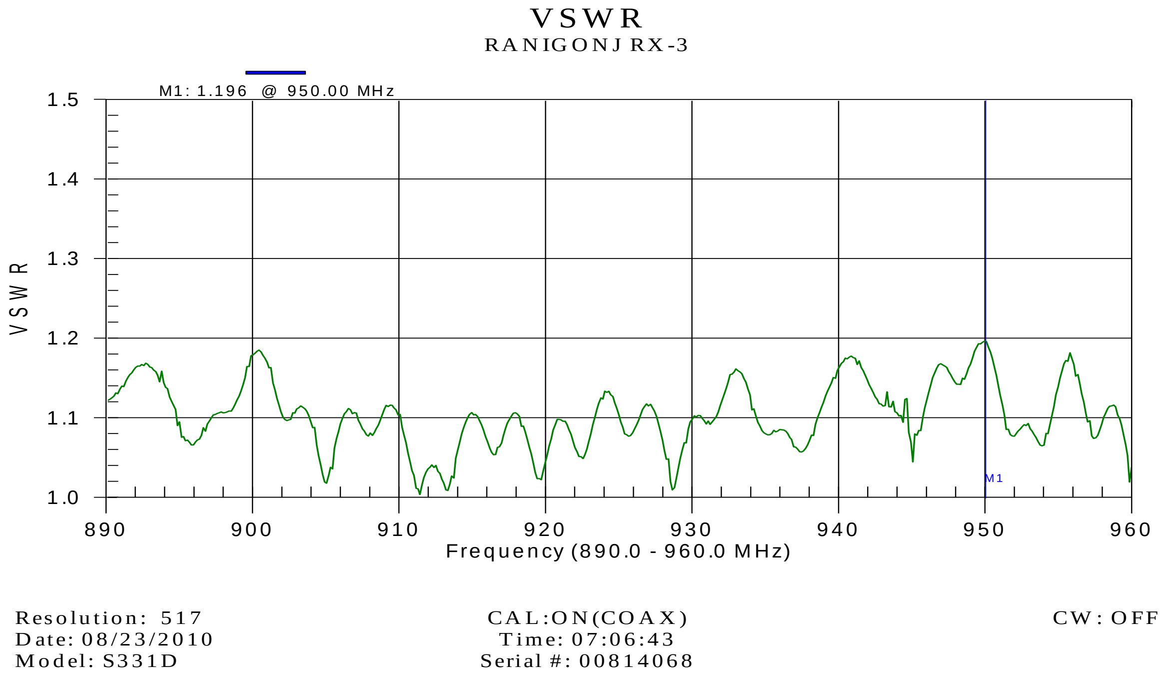
M1: 1.234 @ 956.30 MHz

Resolution: 517
Date: 08/23/2010
Model: S331D

CAL:ON(COAX)
Time: 07:05:28
Serial #: 00814068

CW: OFF

Fig. 5.4 Ranigonj VSWR Rx2 and Tx3



VSWR

RANIGONJ RX-3

Resolution: 517
Date: 08/23/2010
Model: S331D

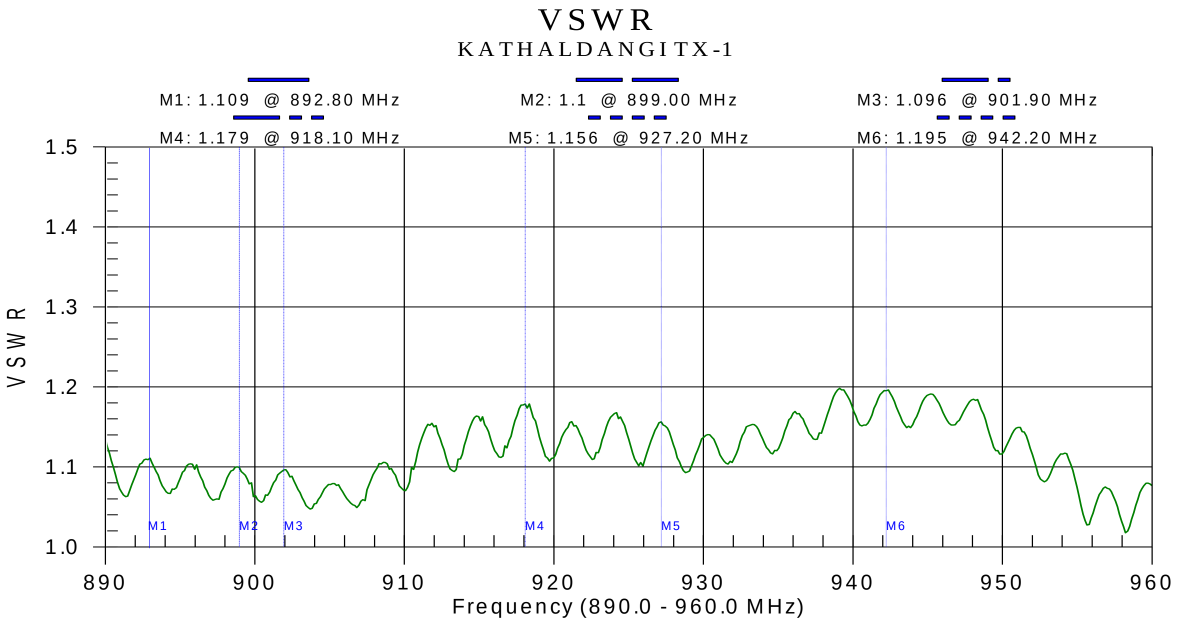
CAL:ON(COAX)
Time: 07:06:43
Serial #: 00814068

CW: OFF

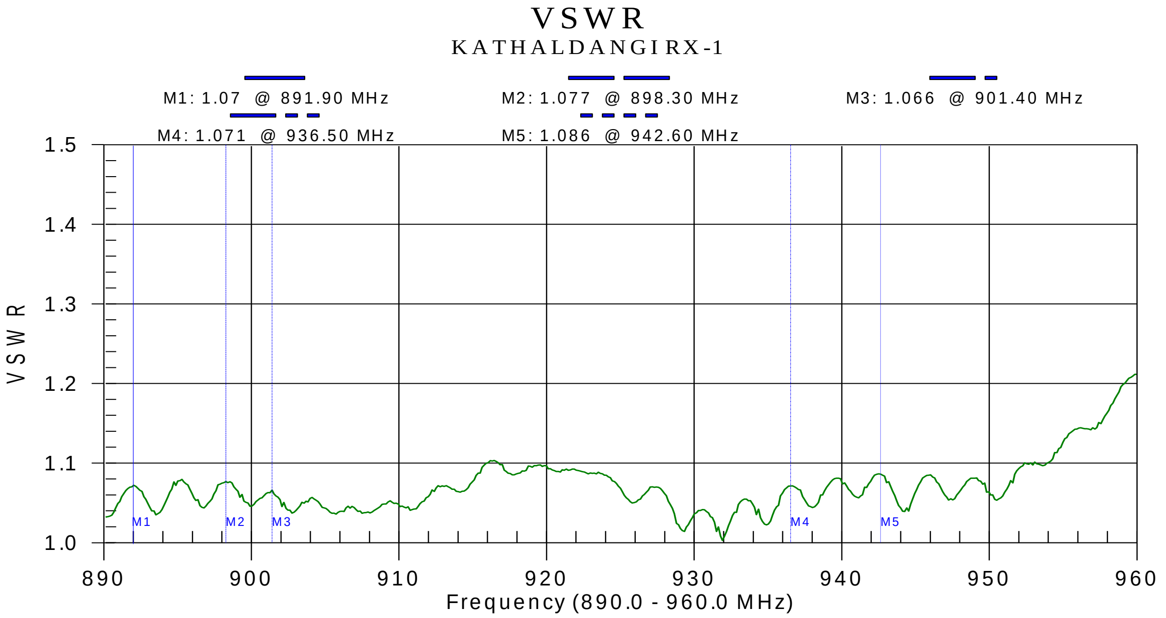
Site Name: Rani Gonj
Atowari, Panchager

Cell 3	VSWR	Frequency Range (890-960 MHz)
Tx 3	1.234	956 MHz
Rx 3	1.196	950 MHz

Fig. 5.5 Ranigonj VSWR Rx3



Resolution: 517 CAL:ON(COAX) CW: OFF
Date: 08/23/2010 Time: 03:44:09
Model: S331D Serial #: 00814068

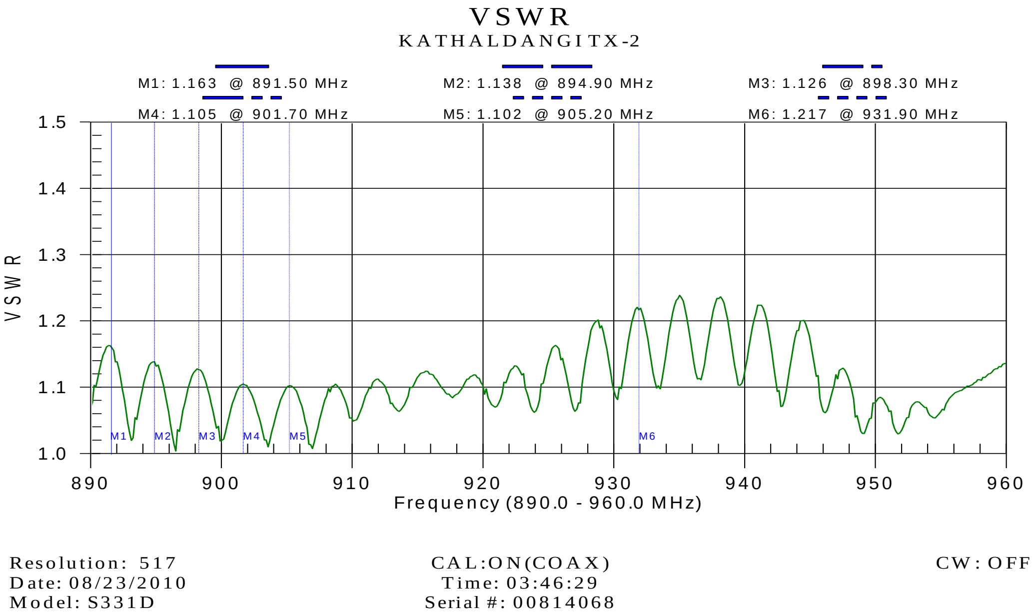


Resolution: 517 CAL:ON(COAX) CW: OFF
Date: 08/23/2010 Time: 03:42:51
Model: S331D Serial #: 00814068

Fig. 5.6 Kathaldangi VSWR Tx1 and Rx1

Site Name: Kathaldangi
Hazir-hat, Pabna.

Cell 1	VSWR	Frequency Range (890-960 MHz)
Tx 1	1.195	942 MHz
Rx 1	1.086	942 MHz



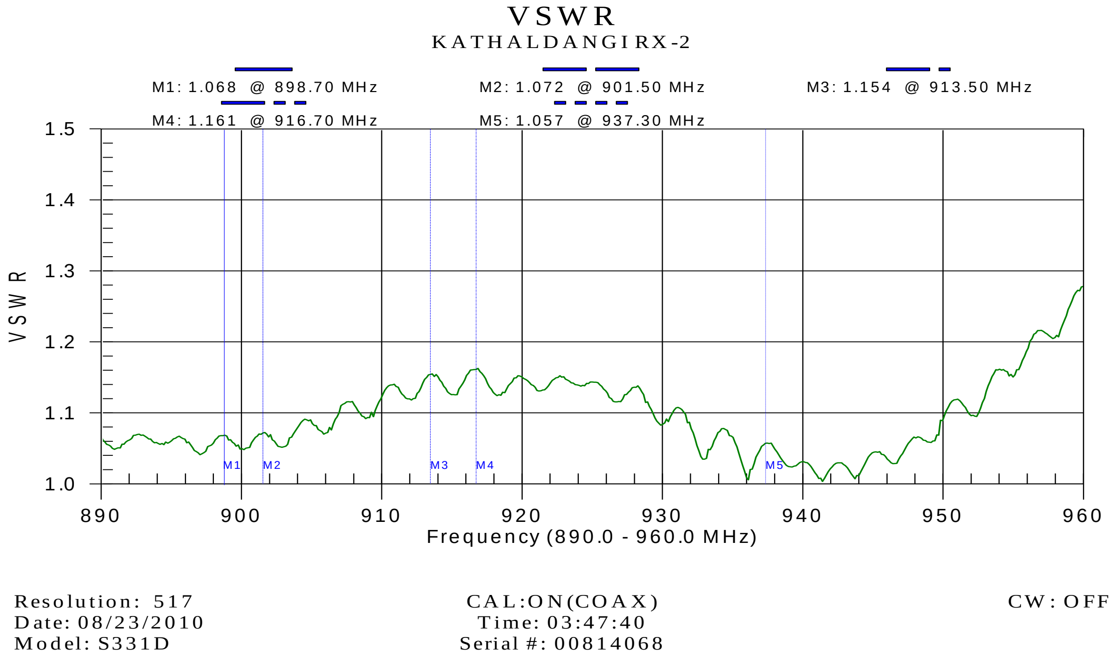
VSWR
KATHALDANGI TX-2

M1: 1.163 @ 891.50 MHz
M2: 1.138 @ 894.90 MHz
M3: 1.126 @ 898.30 MHz
M4: 1.105 @ 901.70 MHz
M5: 1.102 @ 905.20 MHz
M6: 1.217 @ 931.90 MHz

Resolution: 517
Date: 08/23/2010
Model: S331D

CAL:ON(COAX)
Time: 03:46:29
Serial #: 00814068

CW: OFF



VSWR
KATHALDANGI RX-2

M1: 1.068 @ 898.70 MHz
M2: 1.072 @ 901.50 MHz
M3: 1.154 @ 913.50 MHz
M4: 1.161 @ 916.70 MHz
M5: 1.057 @ 937.30 MHz

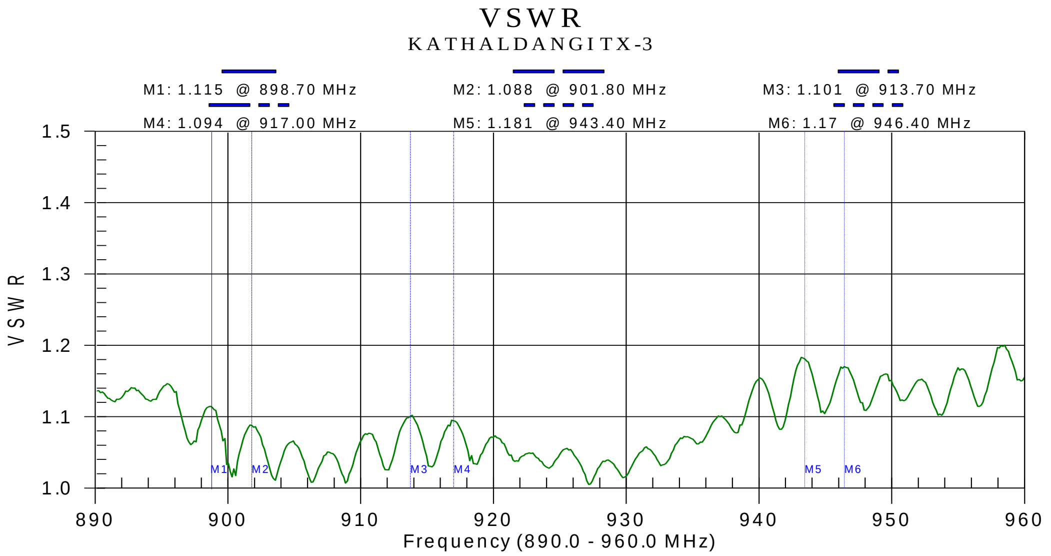
Resolution: 517
Date: 08/23/2010
Model: S331D

CAL:ON(COAX)
Time: 03:47:40
Serial #: 00814068

CW: OFF

Fig. 5.7 Kathaldangi VSWR Tx2 and Rx2
Site Name: Kathaldangi
Hazir-hat, Pabna.

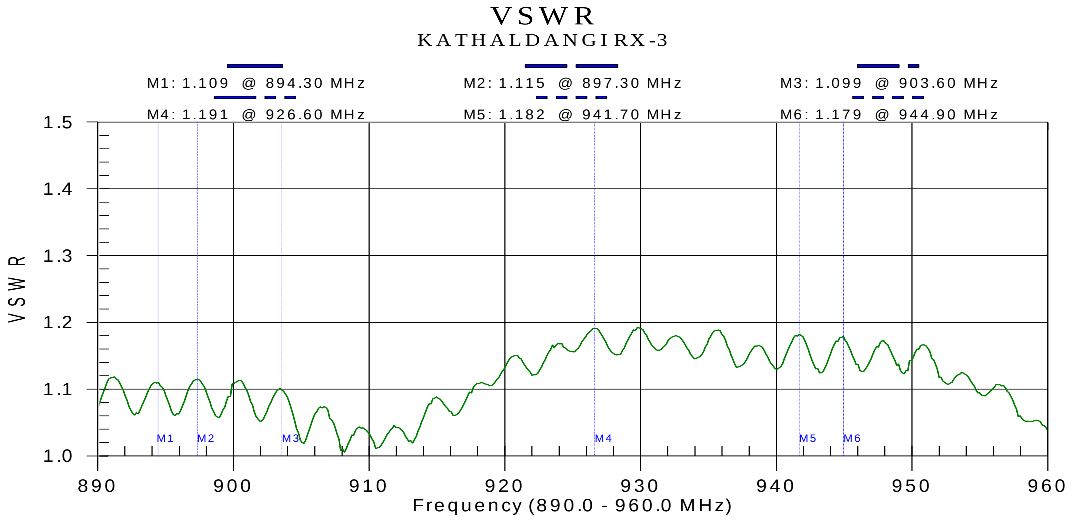
Cell 2	VSWR	Frequency range (890-960 MHz)	Remarks
Tx2	1.217	931.90 MHz	
Rx2	1.161	916.70 MHz	



Resolution: 517
Date: 08/23/2010
Model: S331D

CAL:ON(COAX)
Time: 03:49:33
Serial #: 00814068

CW: OFF



Resolution: 517
Date: 08/23/2010
Model: S331D

CAL:ON(COAX)
Time: 03:50:50
Serial #: 00814068

CW: OFF

Site Name: Kathaldangi

Cell 3	VSWR	Frequency Range (890-960 MHz))
Tx3	1.181	943.40 MHz
Rx3	1.191	926 .60 MHz

Fig. 5.8 Kathaldangi VSWR Tx3 and Rx3

5.6: Analysis:

VSWR is used as an efficiency measure for transmission lines, electrical cables that conduct radio frequency signals, used for purposes such as connecting radio transmitters and receivers with their antennas, and distributing cable television signals. A problem with transmission lines is that impedance mismatches in the cable tend to reflect the radio waves back toward the source end of the cable, preventing all the power from reaching the destination end. SWR measures the relative size of these reflections. An ideal transmission line would have an SWR of 1:1, with all the power reaching the destination and no reflected power. An infinite SWR represents complete reflection, with all the power reflected back down the cable. The SWR of a transmission line is measured with an instrument called an SWR meter, and checking the SWR is a standard part of installing and maintaining transmission lines.

Tx and Rx will be good when the practical value is less than 1.35 then the signal will also be good. That is why network get clearly. When the VSWR increases then the voltage level will be bad.
The reason of increases of VSWR :

- If 7/8 cable more bending
- Connector not made correctly
- Cable damage

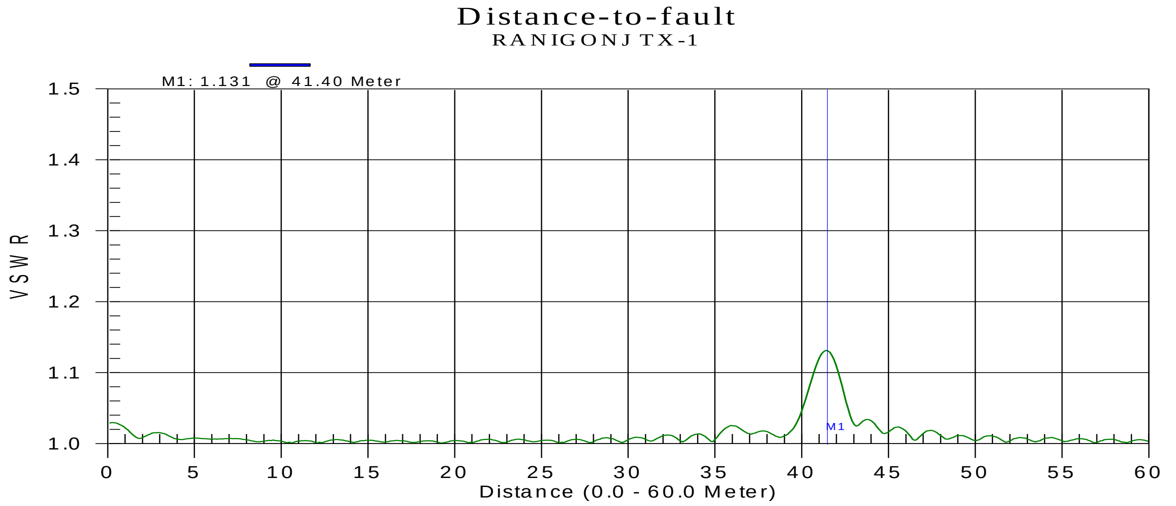
5.7 Understanding the Distance-to-Fault Measurement

5.7.1 Introduction:

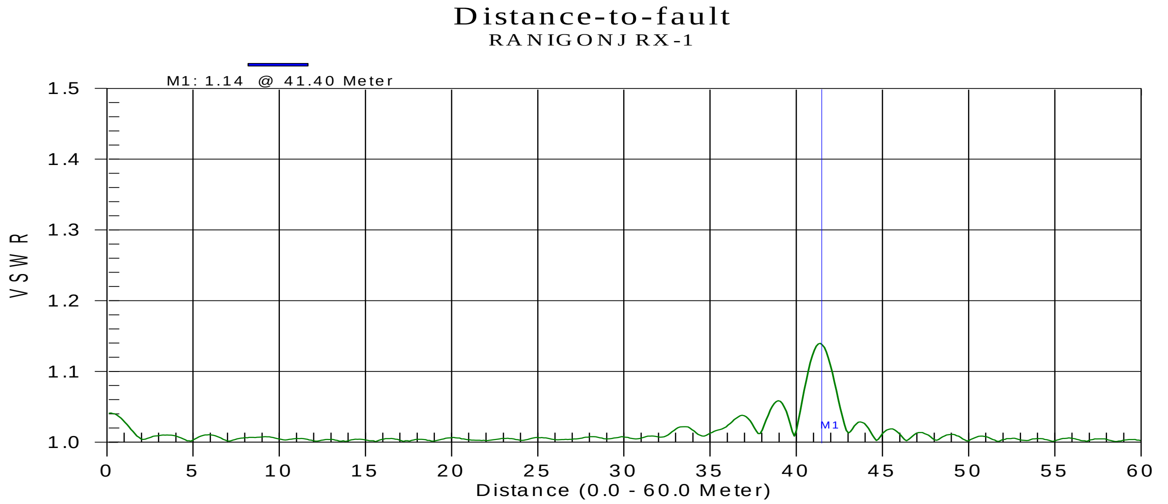
Since its introduction, the Site Master product has taken the mystery out of the RF measurements for many cell site installers. The simplicity of the unit allows a non-RF specialist to measure the cable and the antenna performance accurately as a trained engineer in the lab. However, to understand the measurement still requires experience and technical background. This article provides a short tutorial in interpreting the Distance-to-Fault measurement data. The objective is to provide the non-RF specialist with some understanding of the DTF principle, and thus, allow him to do his job more effectively and efficiently.

5.7.2 Distance-to-Fault:

In order to display the Distance-to-Fault on the Site Master, several steps internal to the Site master have already occurred. First, the Site Master takes the Frequency Domain Reflectometry (FDR) measurement, a fancy name for reflected signals versus frequency or commonly known as return loss (SWR) versus frequency. Second, the built-in IFFT (Inverse Fast Fourier Transform) function converts the reflected signals from frequency domain to time domain. With known relative propagation velocity and cable loss in dB/ft (m), the Site Master transforms the time domain results into distance and displays the return loss (SWR) versus distance on the LCD screen. Any faults will appear to have a high return loss associated with a unique distance. No transmission line component is a perfect impedance match; each reflects some of the RF signals energy. Each antenna system tends to have a unique signal signature because different cable electrical lengths, cable types, dielectric thickness variations and the position of components such as connectors, adapters and lightning arrestors will cause different reflections at different positions in the transmission line.[9]



Resolution: 517	CAL:ON(COAX)	CW: OFF
Date: 08/23/2010	Time: 07:00:28	Ins.Loss:0.039dB/m
Model: S331D	Serial #: 00814068	Prop.Vel:0.800



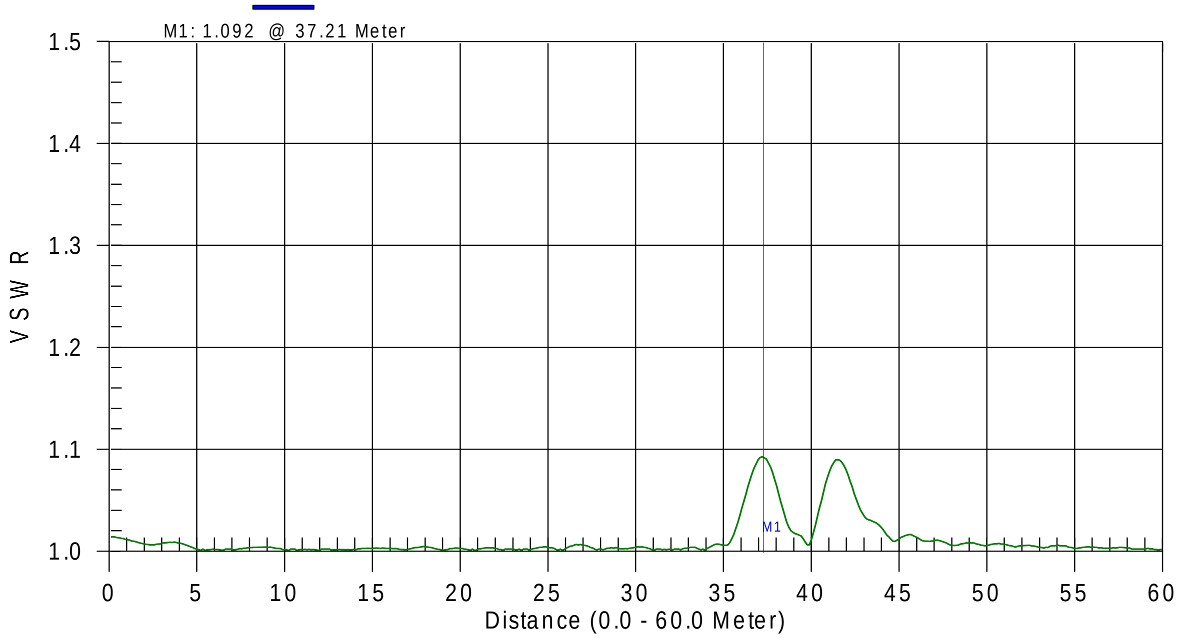
Resolution: 517	CAL:ON(COAX)	CW: OFF
Date: 08/23/2010	Time: 07:01:35	Ins.Loss:0.039dB/m
Model: S331D	Serial #: 00814068	Prop.Vel:0.800

Site Name: Rani Gonj Atowari, Panchager

Cell 1	VSWR	Distance (0.0-60.0 meter)	Remarks
Tx 1	1.131	41.40 Meter	
Rx 1	1.14	41.40 Meter	

Fig. 5.9 Ranigonj DTF Tx1 and Rx1

Distance-to-fault
RANIGONJ TX-2

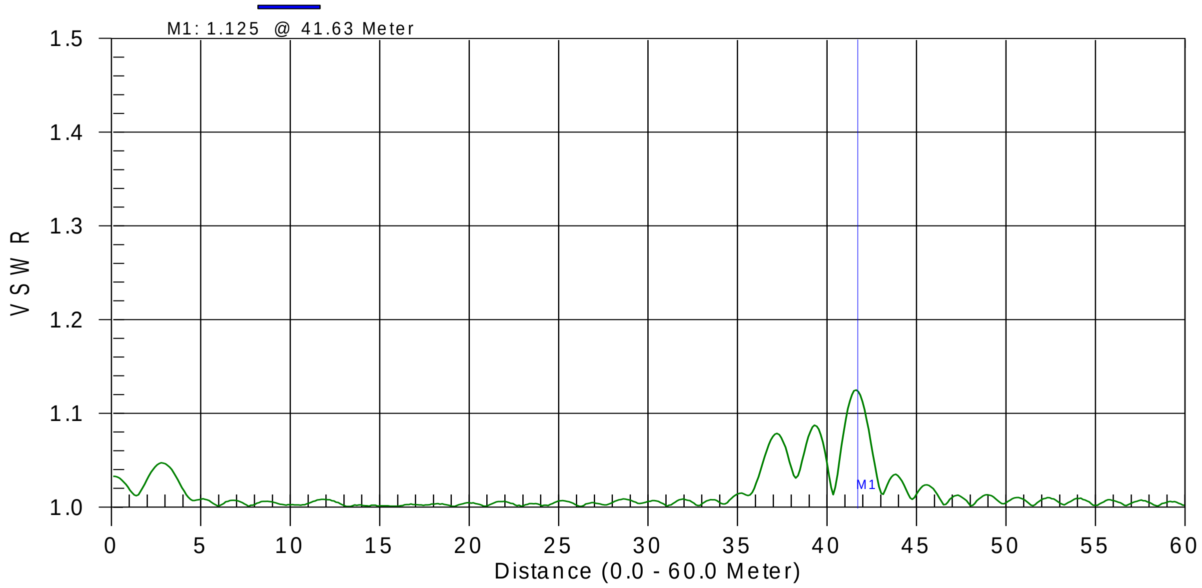


Resolution: 517
Date: 08/23/2010
Model: S331D

CAL:ON(COAX)
Time: 07:03:08
Serial #: 00814068

CW: OFF
Ins.Loss:0.039dB/m
Prop.Vel:0.800

Distance-to-fault
RANIGONJ RX-2



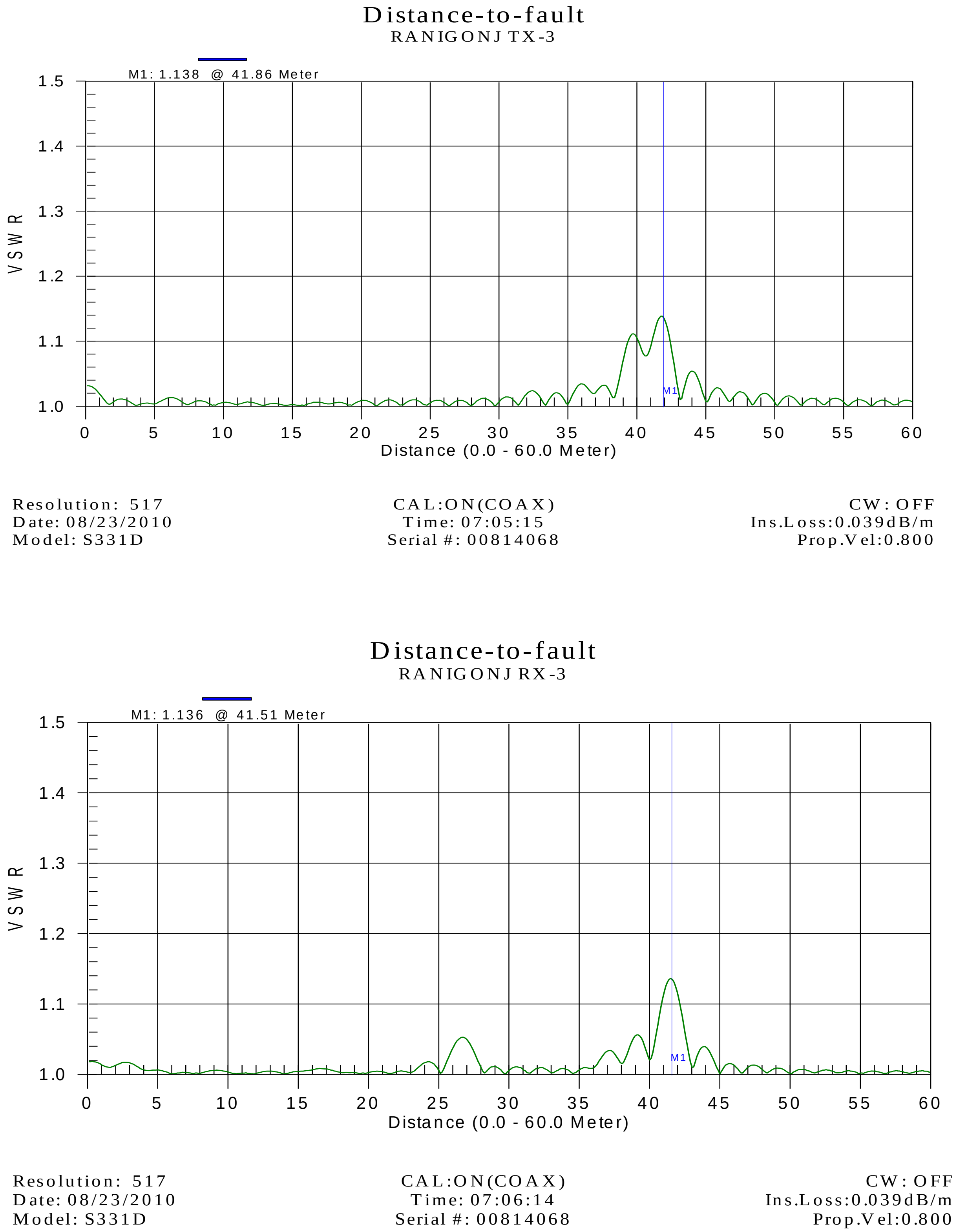
Resolution: 517
Date: 08/23/2010
Model: S331D

CAL:ON(COAX)
Time: 07:04:08
Serial #: 00814068

CW: OFF
Ins.Loss:0.039dB/m
Prop.Vel:0.800

Fig. 5.10 Ranigonj DTF Tx2 and Rx2

Site Name: Rani Gonj Atowari, Panchager



Resolution: 517
Date: 08/23/2010
Model: S331D

CAL:ON(COAX)
Time: 07:05:15
Serial #: 00814068

CW: OFF
Ins.Loss:0.039dB/m
Prop.Vel:0.800

Resolution: 517
Date: 08/23/2010
Model: S331D

CAL:ON(COAX)
Time: 07:06:14
Serial #: 00814068

CW: OFF
Ins.Loss:0.039dB/m
Prop.Vel:0.800

Fig. 5.11 Ranigonj DTF Tx3 and Rx3

Site Name: Rani Gonj Atowari, Panchager

Cell 3	VSWR	Distance (0.0-60.0 meter)
Tx 3	1.138	41.86 meter
Rx 3	1.136	41.51 meter

5.8 Analysis:

The objective of DTF measurement is to observe the value of VSWR in a transmission line. If the VSWR will more than the practical value it will cause the fault then have to find where in a transmission line VSWR is more than the practical value of 2. We have seen from the site of Rani gonj VSWR was 1.31 for 41.4 meter (Tx-1) and 1.14 for 41.4 meter (Rx-1) for cell-1. And VSWR was 1.138 for 41.86 meter (Tx-3) and 1.136 was for 41.51 meter for cell-3. So VSWR was less than the practical value and there was no fault in transmission line.

If a 60 meter transmission line gets VSWR of 2 or more than 2 at the point of 55 meter then have to understand that DTF occur at the point of 55 meter.

Distance-to-Fault (DTF) can cause for

1. Cable Problems -- Coaxial and Twisted-Pair
2. Complete cable faults – open / short
3. Partial cable faults
4. Minor shield, conductor damage, Water ingress.
5. Connector Problems-Low-quality connectors
6. Antenna problems-Variation from installed configuration

5.9 What is RSL:

Received signal level (RSL): The signal level at a receiver input terminal. The signal bandwidth and the established reference level must be specified. The RSL is usually expressed in dB with respect to 1 mW, *i.e.,* 0 dBm [10]

5.9.1 Link Budget:

The link budget is a calculation involving the gain and loss factors associated with the antennas, transmitters, transmission lines and propagation environment, to determine the maximum distance at which a transmitter and receiver can successfully operate Receiver sensitivity threshold is the signal level at which the radio runs continuous errors at a specified bit rate. System gain depends on the modulation used (2PSK, 4PSK, 8PSK, 16QAM, 32QAM, 64QAM,128QAM,256QAM) and on the design of the radio.The gains from the antenna at each end are added to the system gain (larger antennas provide a higher gain). The free space loss of the radio signal is subtracted. The longer the link the higher the lossThese calculations give the fade margin. In most cases since the same duplex radio setup is applied to both stations the calculation of the received signal level is independent of direction.

Receive Signal Level (RSL)

$RSL = P_o – L_{ctx} + G_{atx} – L_{crx} + G_{atx} – FSL$

Link feasibility formula

$RSL \geq Rx$ (receiver sensitivity threshold)

P_o = output power of the transmitter (dBm)

L_{ctx}, L_{crx} = Loss (cable,connectors, branching unit) between transmitter/receiver and antenna(dB)

G_{atx} = gain of transmitter/receiver antenna (dBi)

FSL = free space loss (dB)

The fade margin is calculated with respect to the receiver threshold level for a given bit-error rate (BER). The radio can handle anything that affects the radio signal within the fade margin but if it is exceeded, then the link could go down and therefore become unavailable. The threshold level for $BER=10^{-6}$ for microwave equipment used to be about 3dB higher than for $BER=10^{-3}$. Consequently the fade margin was 3 dB larger for $BER=10^{-6}$ than $BER=10^{-3}$. In new generation microwave radios with power forward error correction schemes this difference is 0.5 to 1.5 dB

Microwave Worksheet: Alipur to Noakhali

	Alipur_New	Noakhali
Elevation (m)	7.53	9.08
Latitude	22 55 43.60 N	22 56 44.54 N
Longitude	091 06 12.10 E	091 07 12.75 E
True azimuth (°)	42.67	222.67
Vertical angle (°)	0.09	-0.11
Antenna model	WTG1.2-144D	WTG1.2-144D
Antenna height (m)	32.00	35.00
Antenna gain (dBi)	42.80	42.80
TX filter loss (dB)	1.70	1.70
RX filter loss (dB)	1.70	1.70
Frequency (MHz)	15000.00	
Polarization	Vertical	
Path length (km)	2.55	
Free space loss (dB)	124.12	
Atmospheric absorption loss (dB)	0.07	
Net path loss (dB)	41.99	41.99
Radio model	15G_SP_16QAM_28M_35E1	15G_SP_16QAM_28M_35E1
Txpower (watts)	3.16e-03	3.16e-03
TX power (dBm)	5.00	5.00
EIRP (dBm)	46.10	46.10
Emission designator	28M0D7W	28M0D7W
TX Channels	2.3-.6' 15348.0000V	2.3-.6' 14914.0000V
RX threshold criteria	BER 10-6	BER 10-6
RX threshold level (dBm)	-78.50	-78.50
RX signal (dBm)	-36.99	-36.99
Thermal fade margin (dB)	41.51	41.51
Geoclimatic factor	1.77E-04	
Path inclination (mr)	1.78	
Fade occurrence factor (Po)	1.36E-04	
Worst month SESR	9.65E-09	9.65E-09
(seconds /month)	0.03	0.03
Rain region	ITU Region P	
0.01% rain rate (mm/hr)	145.00	
Flat fade margin - rain (dB)	41.51	41.51
Rain rate (mm/hr)	265.30	265.30
Rain attenuation (dB)	41.51	41.51

Annual rain outage (min)	3.76	3.76
Annual unavailability	7.14E-06	7.14E-06
minutes /year)	3.76	3.76

Wed, Aug 25 2010
Alipur_New-Noakhali BSC.pl4
Reliability Method - ITU-R P.530-7/8
Rain - ITU-R P530-7

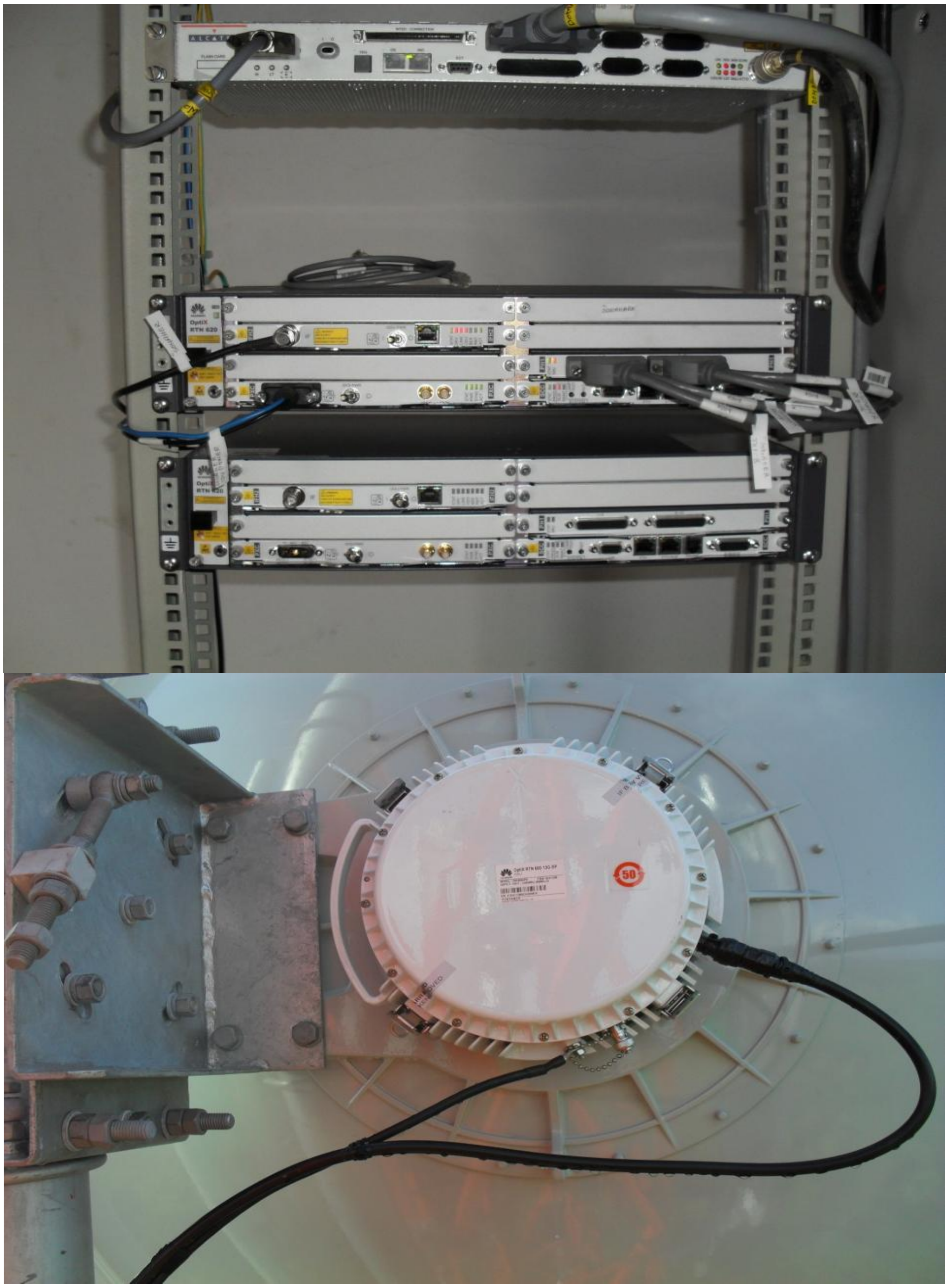
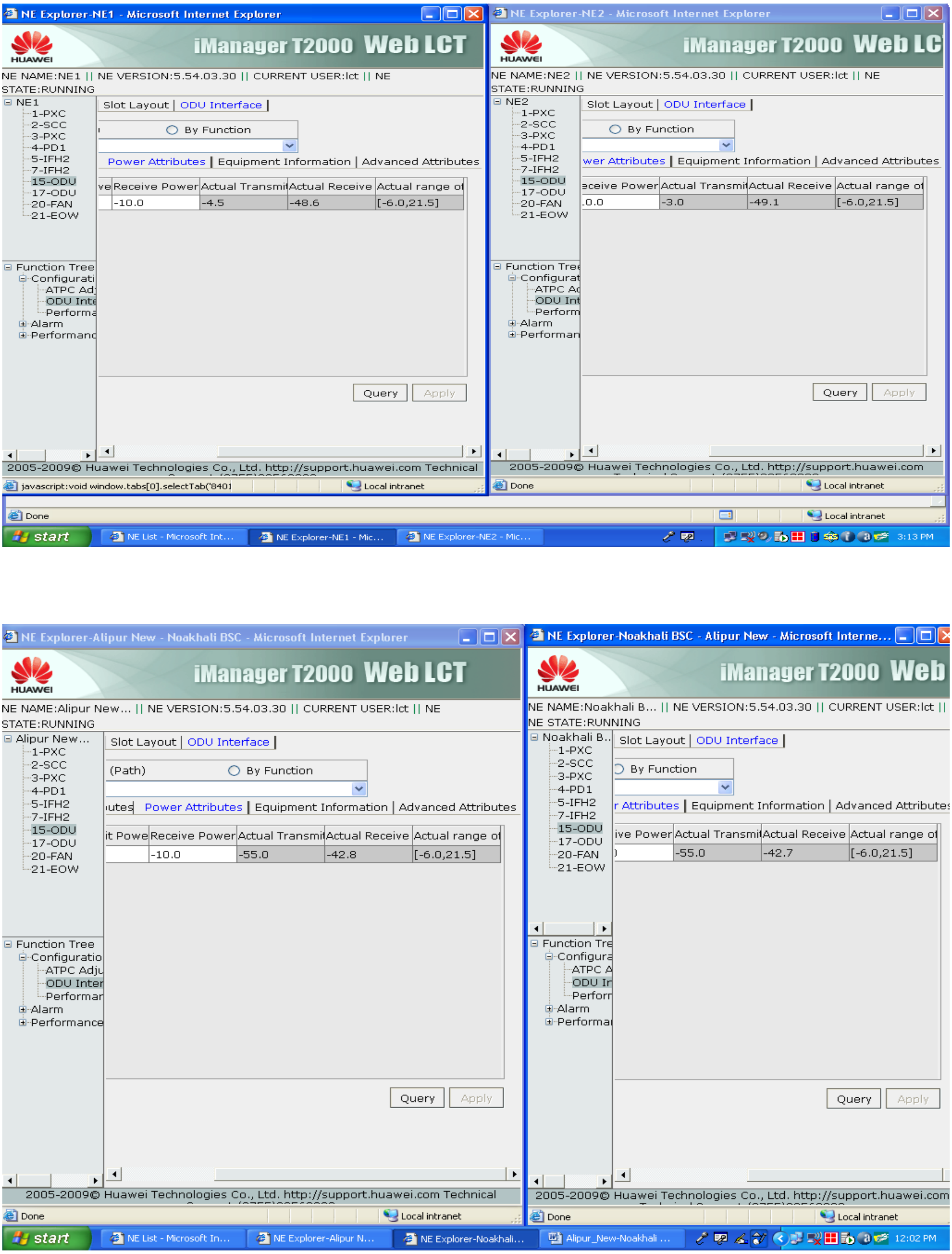


Fig. 5.12 MICRO WAVE ANTENNA WITH IDU & ODU



NE NAME:NE1 || NE VERSION:5.54.03.30 || CURRENT USER:lct || NE STATE:RUNNING

ve	Receive Power	Actual Transmi	Actual Receive	Actual range o
	-10.0	-4.5	-48.6	[-6.0,21.5]

NE NAME:NE2 || NE VERSION:5.54.03.30 || CURRENT USER:lct || NE STATE:RUNNING

eceive Power	Actual Transmi	Actual Receive	Actual range o
.0.0	-3.0	-49.1	[-6.0,21.5]

NE NAME:Alipur New... || NE VERSION:5.54.03.30 || CURRENT USER:lct || NE STATE:RUNNING

it Powe	Receive Power	Actual Transmi	Actual Receive	Actual range o
	-10.0	-55.0	-42.8	[-6.0,21.5]

NE NAME:Noakhali B... || NE VERSION:5.54.03.30 || CURRENT USER:lct || NE STATE:RUNNING

ive Power	Actual Transmi	Actual Receive	Actual range o
)	-55.0	-42.7	[-6.0,21.5]

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javascript:void window.tabs[0].selectTab('8401

Fig. 5.12 RSL PRINT SCREEN

SITE NAME: NOAKHALI BSC TO ALIPUR(BER TES TREPORT)

START DATE :10/08/16
STOP DATE :10/08/16
START TIME :09:02:22
STOP TIME :09:02:22
FRAMING : PCM-30C
INPUT : TERM
TX CLOCK : INTERNAL
MODE : E1
SIGNAL/FREQUENCY
LVL : -1.8 dB
REC Hz:2048000 REC PPM:+0.0
MAX Hz:2048000 MAX PPM:+0.0
MIN Hz:2048000 MIN PPM:+0.0
CLKSLP : N/A

ERRORS	COUNT	RATE
CODE	0	0.0e-11
FRAME	0	0.0e-09
CRC-4	0	0.0e-08
E BIT	0	0.0e-08

ALARMS	COUNT
FAS RAI	0
MFAS RAI	0
ALARM INDICATION	0
SECONDS WITH LOSS OF SIGNAL	0
SECONDS WITH LOSS OF FRAME	0
SECONDS WITH LOSS OF SYNCH	0

PARAMETER	COUNT	RATE/%
G.821		
BIT ERRORS	0	0.0e-11
ERRORED SECONDS	0	00.000
SEVERELY ERROR SECONDS	0	00.000
ERROR FREE SECONDS	43200	100
UNAVAILABLE SECONDS	0	00.000
AVAILABLE SECONDS	43200	100
DEGRADED MINUTES	0	00.000
G.826		
ERRORED BLOCKS	0	0.0e-08
BACKGROUND BLOCK ERROR	0	0.0e-08
SEVERELY ERROR SECONDS	0	00.000
UNAVAILABLE SECONDS	0	00.000
AVAILABLE SECONDS	43200	100
M.2100/550		
ERRORED SECONDS	0	00.000
SEVERAL ERROR SECONDS	0	00.000

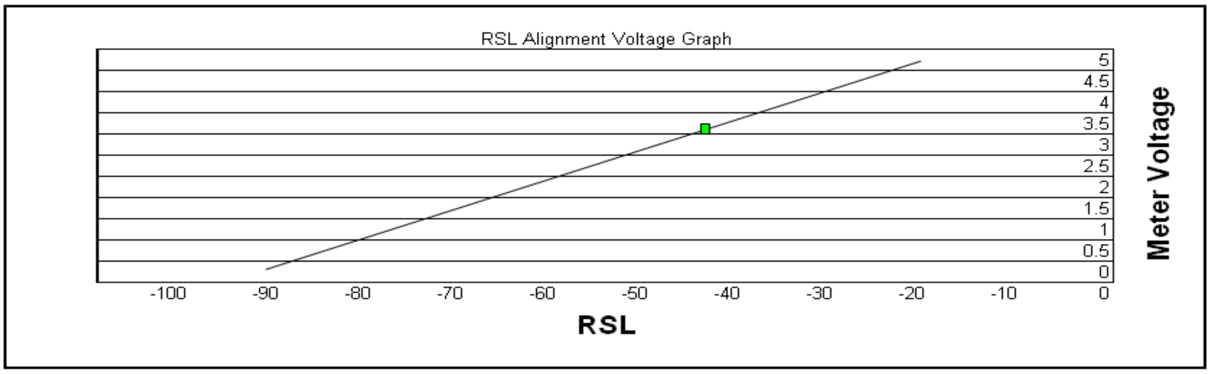
PASS/FAIL PASS

RSL VS METER VOLTAGE TABLE

RSSI Table															
			BNC Output Voltage (for RSSI) and Input Level Look Up Table												
RF Input (dBm)	-20	-25	-30	-35	-40	-45	-50	-55	-60	-65	-70	-75	-80	-85	-90
BNC Outp Voltage (for RSSI)	4.539	4.222	3.905	3.588	3.271	2.9	2.637	2.32	2.003	1.685	1.368	1.051	0.734	0.417	0.1

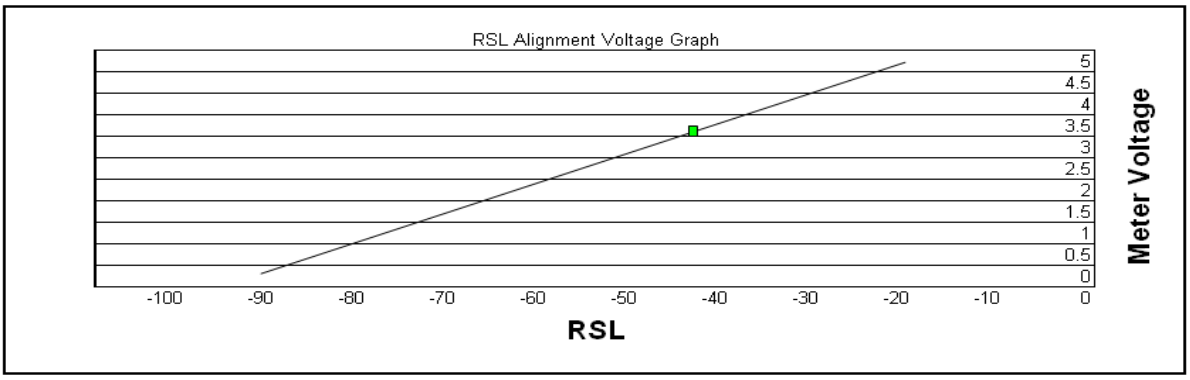
Noakhali to Ali pur RSL Graph-1

Ali pur (42.8)



Noakhali to Ali pur RSL Graph-2

Noakhali BSC (42.7)

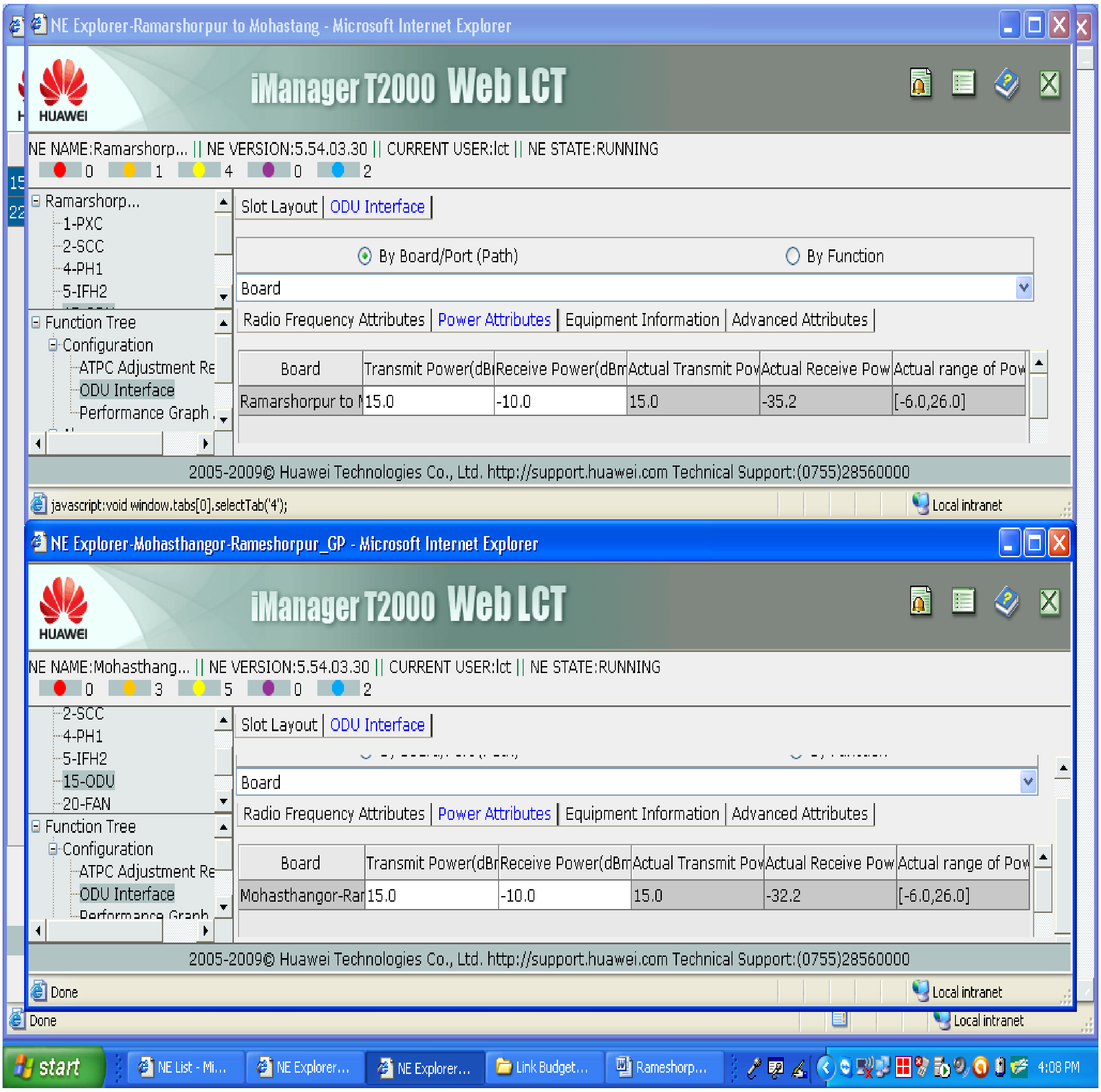


Microwave Worksheet: Rameshorpur to Mohasthangarh

	Rameshorpur_GP	Mohasthangarh
Elevation (m)	21.83	20.84
Latitude	24 55 45.50 N	24 57 03.69 N
Longitude	089 25 08.50 E	089 21 02.14 E
True azimuth (°)	289.21	109.18
Vertical angle (°)	-0.09	0.04
Antenna model	WTG1.2-127D	WTG1.2-127D
Antenna height (m)	37.00	30.00
Antenna gain (dBi)	41.60	41.60
Connector loss (dB)	0.50	0.50
Frequency (MHz)	13000.00	
Polarization	Vertical	
Path length (km)	7.32	
Free space loss (dB)	132.03	
Atmospheric absorption loss (dB)	0.15	
Net path loss (dB)	49.98	49.98
Radio model	13G_SP_QPSK_7M_4E1	13G_SP_QPSK_7M_4E1
TX power (watts)	0.03	0.03
TX power (dBm)	15.00	15.00
EIRP (dBm)	56.10	56.10
Emission designator	7M0D7W	7M0D7W
TX Channels	F1.2L 12761.5000V	F1.2H 13027.5000V
RX threshold criteria	BER 10-6	BER 10-6
RX threshold level (dBm)	-91.00	-91.00
RX signal (dBm)	-34.98	-34.98
Thermal fade margin (dB)	56.02	56.02
Geoclimatic factor	1.77E-04	
Path inclination (mr)	1.09	
Fade occurrence factor (Po)	7.97E-03	
Worst month SESR	2.07E-08	2.07E-08
(seconds /month)	0.05	0.05
Rain region	ITU Region P	
0.01% rain rate (mm/hr)	145.00	
Flat fade margin - rain (dB)	56.02	56.02
Rain rate (mm/hr)	239.32	239.32
Rain attenuation (dB)	56.02	56.02
Annual rain outage (min)	6.65	6.65
Annual unavailability	1.26E-05	1.26E-05
(minutes /year)	6.65	6.65

Mon, Sep 20 2010
Rameshorpur_GP-Mohasthangarh_13G.pl4
Reliability Method - ITU-R P.530-7/8
Rain - ITU-R P530-7

RAMESHSORPUR-MOHASTHANGARH RSL PRINT SCREEN



NE NAME:Ramarshorp... || NE VERSION:5.54.03.30 || CURRENT USER:lct || NE STATE:RUNNING

● 0 ● 1 ● 4 ● 0 ● 2

● By Board/Port (Path) ○ By Function

Board

Board	Transmit Power(dBı	Receive Power(dBm	Actual Transmit Pov	Actual Receive Pow	Actual range of Pow
Ramarshorpur to I	15.0	-10.0	15.0	-35.2	[-6.0,26.0]

2005-2009© Huawei Technologies Co., Ltd. http://support.huawei.com Technical Support:(0755)28560000

NE NAME:Mohasthang... || NE VERSION:5.54.03.30 || CURRENT USER:lct || NE STATE:RUNNING

● 0 ● 3 ● 5 ● 0 ● 2

Board

Board	Transmit Power(dBı	Receive Power(dBm	Actual Transmit Pov	Actual Receive Pow	Actual range of Pow
Mohasthangor-Rar	15.0	-10.0	15.0	-32.2	[-6.0,26.0]

2005-2009© Huawei Technologies Co., Ltd. http://support.huawei.com Technical Support:(0755)28560000

Fig. 5.12 RSL PRINT SCREEN

SITE NAME: NOAKHALI BSC TO ALIPUR (BER TEST REPORT

START DATE :10/08/15

STOP DATE :10/08/16

START TIME :16:02:22

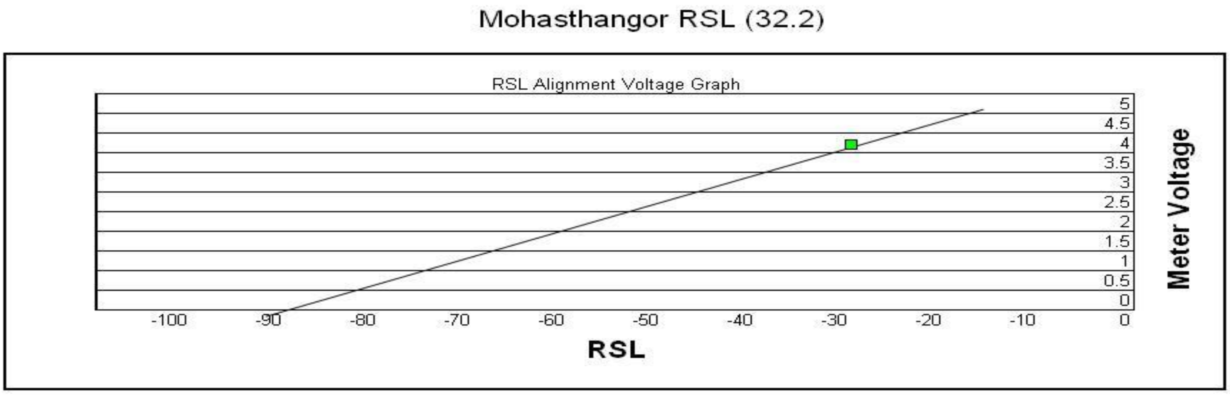
```
STOP TIME                  :04:02:22
FRAMING                    : PCM-30C
INPUT                      : TERM
TX CLOCK                   : INTERNAL
MODE                       : E1
SIGNAL/FREQUENCY
LVL                        : - 1.8 dB
REC Hz:2048000     REC PPM:+0.0
MAX Hz:2048000     MAX PPM:+0.0
MIN Hz:2048000     MIN PPM:+0.0
CLKSLP : N/A
ERRORS             COUNT              RATE
CODE                 0                0.0e-11
FRAME                0                0.0e-09
CRC-4                0                0.0e-08
E BIT              0                  0.0e-08
ALARMS                               COUNT
FAS RAI                                0
MFAS RAI                               0
ALARM INDICATION SIGNAL          0
SECONDS WITH LOSS OF SIGNAL      0
SECONDS WITH LOSS OF FRAME       0
SECONDS WITH LOSS OF SYNCH       0

PARAMETER                        COUNT          RATE/%
G.821
BIT ERRORS                         0            0.0e-11
ERRORED SECONDS                    0            00.000
SEVERELY ERROR SECONDS             0            00.000
ERROR FREE SECONDS               43200          100
UNAVAILABLE SECONDS                0            00.000
AVAILABLE SECONDS                43200          100
DEGRADED MINUTES                   0            00.000
G.826
ERRORED BLOCKS                     0            0.0e-08
BACKGROUND BLOCK ERROR             0            0.0e-08
SEVERELY ERROR SECONDS             0            00.000
UNAVAILABLE SECONDS                0            00.000
AVAILABLE SECONDS                43200          100
M.2100/550
```

ERRORED SECONDS	0	00.000
SEVERAL ERROR SECONDS	0	00.000
PASS/FAIL	PASS	

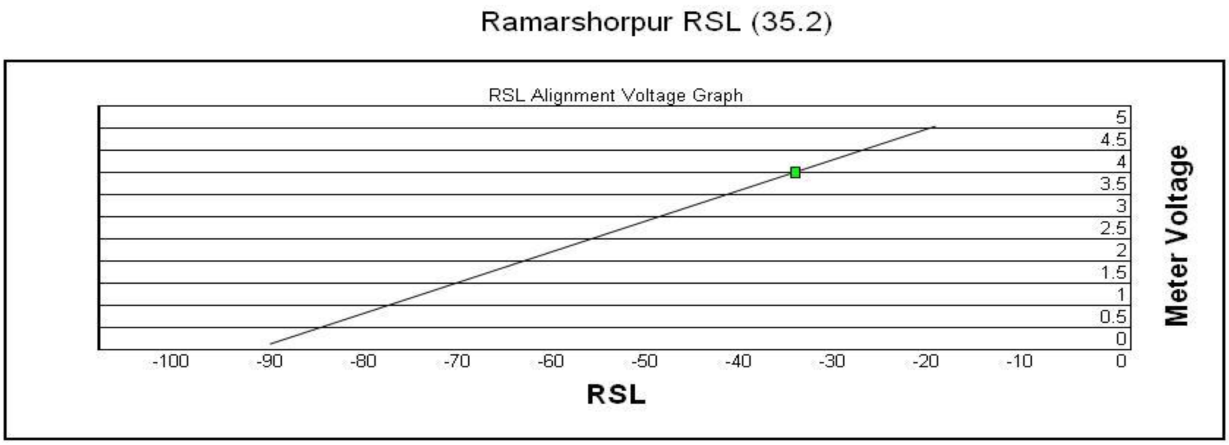
RSL VS METER VOLTAGE TABLE

RSSI Table															
			BNC Output Voltage (for RSSI) and Input Level Look Up Table												
RF Input (dBm)	-20	-25	-30	-35	-40	-45	-50	-55	-60	-65	-70	-75	-80	-85	-90
BNC Output Voltage (for RSSI)	4.539	4.222	3.9	3.5	3.271	2.9	2.637	2.32	2.003	1.685	1.368	1.051	0.734	0.417	0.1

Mohasthangor to Ramarshorpur RSL Graph-1



Mohasthangor to Ramarshorpur RSL Graph-2



5.9.2 Analysis:

When the RSL value is (32-40) then signal transfer level will be very good otherwise receive signal level will not be good. We have seen from Mohasthangor to Ramarshorpur RSL Graph-1, RSL was -32.2 then the meter voltage was 3.7 and from the graph-2 , RSL was -35.2 then the meter voltage was 3.6 So the RSL was perfect. But for the site of Noakhali to Ali pur RSL Graph-1, RSL was -42.8 then the meter voltage was 3.31 and from the graph-2, RSL was -42.7 and the meter voltage was 3.31 So the RSL was not perfect because of it was more than the value of RSL (32-40)

There are some cause for not to get the perfect level of receive signal

1. If have A lot of towers of another operator in front of antenna
2. Cloudy weather
3. If alignment done in the evening

CONCLUSION

Microwave communication is playing a very vital role in the field of communication. Especially the field of cellular systems is highly dependent on Microwave link. One of the very vital part of a microwave link is its transmission line .We always have to consider the loss factors that take place in the transmission line while measuring the performance of a Microwave Communication Link. In this project we have conducted some analysis to measure the performance a Microwave Transmission Line. For conducting the experiments we have considered three parameters: VSWR, DTF and RSL and collected data for the parameters. After executing the experiment on VSWR, it is found that the site of Ranigonj and Kathaldangi, Tx and Rx will be very good when the practical value is less than 1.35 then the signal level will also be good. This is one of the reasons why the network showed a good performance. When the VSWR increases then the voltage level will also be bad. Again from the test on DTF it is found that if the VSWR is more than the practical value then definitely there is fault in the transmission line and we have to find out the location of the fault. If a 60 meter transmission line gets VSWR of 2 or more than 2 at the point of 55 meter then have to understand that DTF occurs at the distance of 55 meters. Finally the analysis on RSL shows the RSL if value is (32db-40db) then signal transfer level will be very good otherwise received signal level will not be good.

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