SECTION I

EXPERIMENTS AND DESIGNS

CHAPTER I

INTRODUCTION

1-1 Introduction

In communication between point-to-point by HF radio wave in intermediate distance as in domestic circuit, the antennas that are useful for this purpose are log-periodic and half wave dipole antennas.

The log-periodic antenna is very well suited for this purpose, because of its properties of high directivity and gain and the most important of all is the property of frequency independence, if its cost does not concern. The log-periodic antennas as produced by many companies usually have wide frequency band (3 to 30 Mc), but the frequency band that is well suited to our domestic circuit is 3 to 10 Mc. So if we can design a log-periodic antenna that has the frequency range as specified, then the capital cost will be much less because the unnecessary higher frequency elements could be neglected in the design. The remaining is the elements which are actually used in radiating.

This thesis presented a step by step procedure which enables one to design a log-periodic dipole antenna over a wide range of input impedance, bandwidth, directivity and antenna size. A typical LPD antenna with frequency range 3 to 10 Mc for use in domestic circuit is also designed as an example. The agreement between the measured and design value is about what can be expected. This antenna is believed to be useful.

Now consider the half-wave dipole antenna. It may be less in the case of directivity gain and bandwidth than that of the log-periodic antenna, but its cost is very much lower. Besides, its much easier to set up, its the simplest and shortest type of ungrounded resonant antenna that can be designed. It will work well for such intermediate distance, because of its high wave angle and at the same time the field strength from the transmitters are powerful enough. We may think of the dipole antenna as the gradual compromise of technical perfection in the interests of lower capital costs. Because of these reasons, the half-wave dipole antenna is by far the most widely used type of antenna for almost all radio frequency applications. But the biggest drawback of the dipole antenna is that one set of antenna can be used for one frequency only. Also, it has bidirectional pattern which should be equipped with parasitic elements when point-to-point service is required. So in using the dipole antenna for 24 hours application, one should have two sets of them, one cut for day frequency and the other for night frequency, both frequencies have the ratio of almost 2 : 1 . This tends to be waste of land and can make a seemingly inexpensive structure be infact a costly one. So if there is some way of utilizing the dipole antennas for 24 hour service with minimum cost and takes as little land area as possible, then the ecuomy way of communication will be achieved.

The experiment in this thesis demonstrates a promising new approach to the use of dipole antennas with reflectors effectively as a HF point-to-point antenna with small land area as possible. The experimental result shows that with two dipole antennas connected in parallel on the same support and fed with one feed line (double doublet), and also provided with reflectors for better directivity, the whole set can be used effectively at both day and night frequencies without switching circuit when changing bands. The antenna set possesses constant input impedance at 48 ohms, gain over dipole at about 4.5 db, front-to-back ratio at about 2.3 at both frequencies which is quite high for this kind of antenna. The take-off angles at both frequencies are also suitable for propagations. The guide diagram of the antenna set is also provided with all dimensions as a function of wavelengths. Hence this antenna set is applicable to any set of day and night frequencies selected and especially very suitable for use in domestic circuit, and expected to be widely used.

1-2 Definition Terms[1]

For further clear understanding, following definition of terms should be included.

Antenna (Aerial). A mean for radiating or receiving radio waves.

Isotropic Antenna. A hypothetical antenna radiating or receiving equally well in all directions.

Electric Dipole.(Doublet). A pair of equal and opposite charges an infinitesimal distance apart.

Antenna Array. A system of antennas coupled together for the purpose of obtaining directional effects.

Omnidirectional Antenna. An antenna producing essentially constant field strength in azimuth and a directive radiation pattern in elevation.

Unidirectional Antenna. An antenna which has a single well-defined direction of maximum radiation.

Radiating (Driven) Element. A basic subdivision of an antenna array which in itself is capable of radiating or receiving r-f energy.

<u>Parasitic Element</u>. A radiating element, not coupled directly to the feed line of the antenna array, which materially affects the pattern of the antenna.

<u>Dipole Antenna</u>. A straight radiator, usually fed in the center and producing a maximum of radiation in the plane normal to the axis. A half-wave ($\lambda/2$) linear radiator is usually called a half-wave dipole.

<u>Antenna Resistance</u>. The power supplied to the entire antenna circuit divided by the square of the effective (rms) antenna current referred to a specified point. Antenna resistance is made up of such components as radiation resistance, ground resistance, r-f resistance of conductors in the antenna circuit, and the equivalent resistance due to corona, eddy currents, insulator leakage, and dielectric power loss.

<u>Radiation Resistance</u>. The power radiated by the antenna divided by the square of the effective (rms) antenna current referred to a specific point, usually where power is introduced.

<u>Self Impedance</u>. The ratio of the impressed voltage and the current at the feed point of a single radiating element in the absence of any influences from other radiators or ground.

<u>Mutual Impedance</u>. The mutual impedance Z_{21} of two coupled antennas isdefined as the negative of the emf V_{12} induced in antenna 2 by the current I_1 flowing in antenna 1 divided by I_1 with the terminals of antenna 2 open-circuited. By reciprocity $Z_{12} = Z_{21}$.

<u>Direction of Polarization</u>. In a linearly polarized electromagnetic wave; the direction of the electric-field vector.

<u>Power Density</u> (Poynting Vector). In a given direction, the time rate of energy (i.e., power) flow per unit area in that direction.

Radiation Intensity. In a given direction, the power radiated from an antenna per unit solid angle in that direction.

Radiation Pattern. A graphical representation of the radiation from an antenna as a function of direction. Cross section in which radiation patterns are frequently given are the vertical and horizontal planes, or the principal electric and magnetic planes.

Radiation Lobe. A portion of the radiation pattern bounded by one or two cones of nulls.

Cone of Null. A conical surface formed by directions of negligible radiation.

Major Lobe.(Main Beam). The radiation lobe containing the direction of maximum radiation.

Minor Lobe (Side Lobe). Any lobe except the major lobe.

Directive Gain. In a given direction and relative to an isotropic antenna, it is 4π times the radiation intensity in that direction divided by the total power radiated by the antenna. Also the radiation intensity in that direction divided by the average radiation intensity radiated by the antenna (sometimes called gain; see power gain).

Directivity. The value of directive gain in the direction of its maximum value.

Power Gain. In a given direction and relative to an isottopic antenna, it is 4π times the radiation intensity in that direction divided by the total power delivored to the antenna (sometimes called gain; see directive gain).

Node. Point of zero or minimum voltage or current.

Antinode. Point of maximum voltage or current.

Balun. A device which transforms an unbalanced input to a balanced output.

Critical Angle. The smallest angle away from the vertical at which a radiated wave of a given frequency will be reflected by the ionosphere.

Critical Frequency. The highest frequency which will be reflected back from the ionosphere when transmitted in a vertical direction.

Wave Angle. The angle between the horizontal and the direction in which the wave leaves the transmitting antenna.

1-3 Multiband Antenna

One antenna used for a number of different operating frequencies means first of all that the radiation pattern for each frequency will be different, often vastly different. At some frequencies the radiation patterns may be very unfavorable for communication in the desired direction. Some users make up for this radiation deficiency by employing relatively high power. As spectrum space becomes more valuable, this inefficient expedient will becomes less tolerable, because it causes more interference than properly engineered system.

A single antenna used for a number of frequencies also has the characteristic of widely different input impedances so that there cannot be a universal impedance match. This necessitates the switching of individual impedance-matching networks for each frequency or the readjustment of the coupling circuits for each frequency.

There are several well-known ways of achieving multiband operation with one antenna. It is most often accomplished by the use of tuned feeder, or a long wire feed at the end without feeder. This requires an antenna tuner. To change bands, it is necessary to change coils in the tuner, rearrange taps, and retune. On the other hand, if the single antenna is fed with a nonresonant line, its operation must be limited to the one band for which it is cut.

A dipole antenna that is center-fed by a solid-dielectric line is useless for even harmonic operation, on all even harmonics there is a voltage maximum occuring right at the feed point, and the resonant impedance mismatch causes a large standing-wave ratio and consequently high losses arise in the solid dielectric. It is wise not to attempt to use on its even harmonics a half-wave antenna center-fed with coaxial cable. On odd harmonics, as between 7 and 21 Mc, a current loop will appear in the center of the antenna and a fair match can be obtained. But when the same antenna is used for work in several bands, the directional characteristics will vary with the band in use.

When service to a fixed point or along a fixed direction is wanted, the double doublet is used because at least the maximum field strength is always radiated in the same direction as the frequency is changed over a range of more than 2:1. However, the vertical beam angle will change with frequency if the physical height remains fixed, but fortunately, this behavior has an advantage on propagation. Where one set of antenna must be used for day and night frequencies over a given fixed path, this antenna is useful.

1-4 Double Doublet Antenna

The double doublet antenna is a simple multiband system that could be fed efficiently with coaxial cable.

Fig. 1-1 Double doublet antenna.

The principle of the system is shown in Fig. 1-1. The arrangement consists of seperate dipoles for each band, both are connected in parallel to a single coaxial transmission line. With the shorter one operating at its resonant frequency, its feed point impedance will, of course, be suitable for matching a low-impedance line (approximately 70 ohms). The remaining lower-frequency dipole will be at or close to harmonic resonance at the operating frequency. However, since their halves will be in phase, the impedance presented to the line will be high and essentially resistive. This high impedance will be in parallel with the 70 ohms of the active dipole and therefore will have negligible effect on the line termination, and little current will flow to the longer dipole. In the same manner, when the longer dipole is operating at its resonant frequency, its feed point impedance will, of course, also be about 70 ohms. The remaining higher-frequency dipole will present an impedance consisting of resistance and capacitive reactance. However, the resulting impedance will also be high compared to the 70 ohms of the active dipole. Therefore, it will have negligible effect on the line termination, and little current will flow to the shorter dipole.

Since the active dipole represents a fairly-close match to the line, considerable power will be fed to it. So we may regard the double doublet antenna as a simple half-wave dipole for a frequency band in which it is operated.