Radio Communications in Tunnels

A THESIS

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Radio Communications in Tunnels

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2. Elasticity
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SUMMARY

SUMMARY

A study of radio communication in the underground metero tunnel of the city of Cairo, Egypt was carried out. A part of the tunnel was selected, from Ramses station to Ismail Abaza station, which has a rectangular shape.

The propagation of electromagnetic waves in tunnels would be compared with wave-guide surrounded by a dielectric medium as concrete walls or earth. This also applies to mine and transportation tunnels. Tunnels usually have different shapes, but the most common are the rectangular and the circular types. As far as considering the three cases of wave-guide, i.e. transverse electromagnetic waves (TEM), transverse magnetic waves (TM) and transverse electric waves (TE), they were all studied in both the rectangular and circular wave-guide. Also, the study included the definitions of the cutoff frequency and the attenuation constant.

In the case of the tunnel being studied, as far as his walls are made of concrete, its conductivity coefficient would be in the range 10^{-1}- 10^{-2} mho/m. The cutoff frequency was also calculated and three different types of frequency ranges were characterized. Each of the frequency range is characterized, in turn, by certain propagation modes which differ in the cases of transverse electric

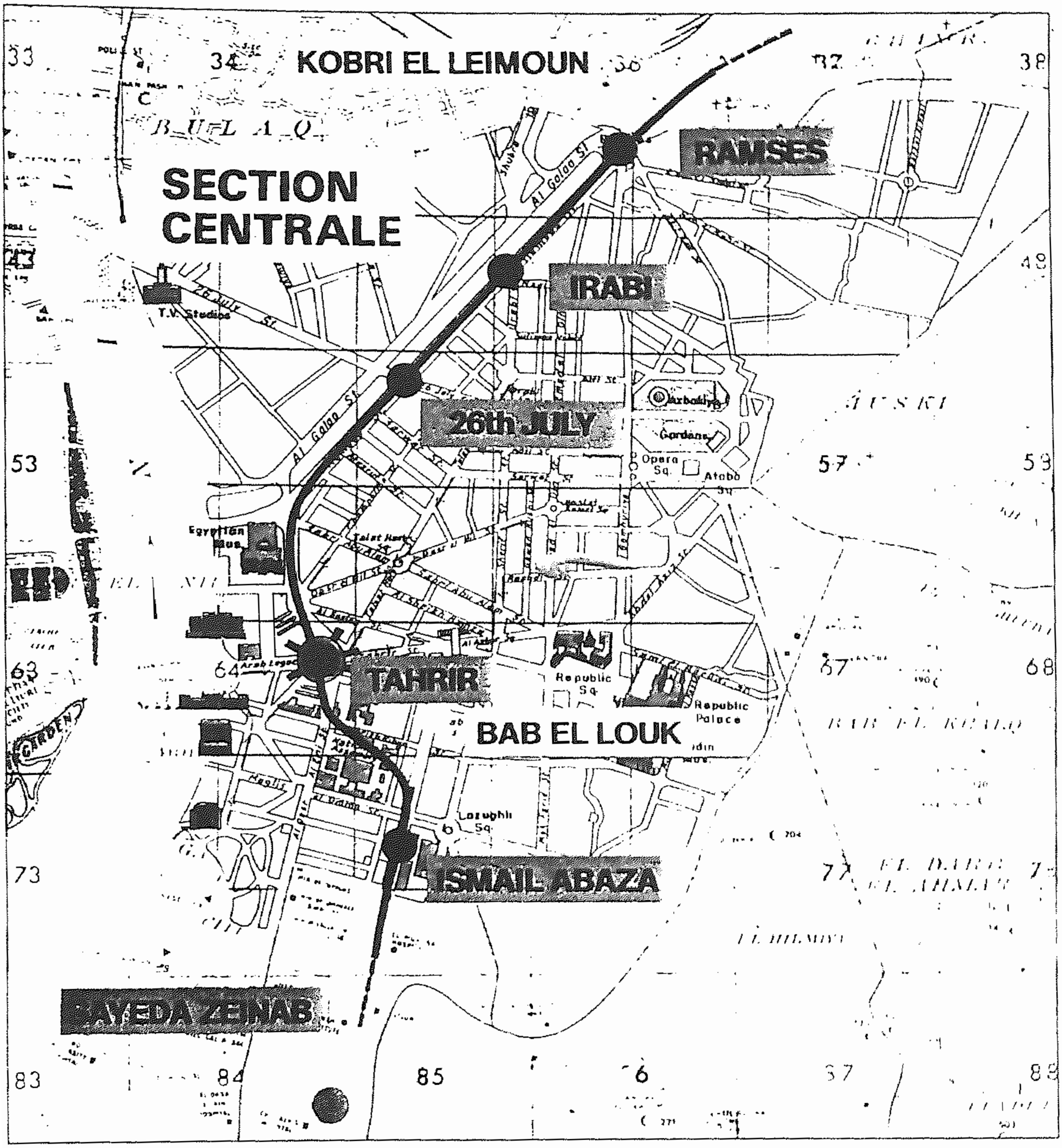
modes (TE_{mn}- modes) and transverse magnetic modes (TM_{mn}- modes), (m,n = 0,1). Besides, the attenuation constant was calculated at values larger and smaller than that of the cutoff frequency for both the transverse electric waves and transverse magnetic waves in either the rectangular and the circular tunnels.

In conclusion, the thesis includes an introduction, and three chapters. The introduction is a survey on the previous studies on different tunnels.

The first chapter discuss and present the general equations for the electromagnetic field as a general case of wave-guides and as a special case of rectangular and circular wave-guides.

The second chapter discusses the study of The electromagnetic wave propagation in a rectangular tunnel and calculating the attenuation constant. Then the numerical results were graphically drawn.

The third chapter discusses the study of the electromagnetic wave propagation in a circular tunnel. Also, the numerical results obtained corresponding to a range of selected frequencies :20 - 600 MHz.



Map of Cairo's Underground Metero

Introduction

INTRODUCTION

1) GENERAL CONCEPTS ABOUT A WAVEGUIDE :

A hollow conducting tube used to transmit electromagnetic waves is termed a waveguide. A waveguide is thus could be considered as a structure, or part of a structure, that causes a wave to propagate in a chosen direction with some measure of confinement in the planes traverse to the direction of propagation.

Any configuration of electric and magnetic fields that exists inside a waveguide must be a solution of Maxwell's equation. In addition, their fields must satisfy the boundary conditions imposed by the walls of the guide. To the extent that the walls are perfect conductors, there can therefore be no tangential component of electric field at the walls. Many different field configurations can found that meet these requirements. Each such configuration is termed a mode. The waveguide concept of terestrial radio wave propagation has been particularly useful in the very low frequency range (i. e. 3-30 GHz).

Generally, in waveguide analysis we are interested in the distribution of the electromagnetic fields, "but of greatest importance is the dependence of" the propagation constant upon frecuency. From the propagation constant one finds wave velocities, phase variation, attenuation along the guide, and the pulse dispersion properties of the guide.

A critical examination of the various possible field configurations or modes that can exist in a waveguide reveals that they all belong to one or the other of two fundamental types. In one type, the electric field is everywhere transverse to the axis of the guide, and has no component anywhere in the direction of the guide axis, the associated magnetic field does, however, have a component in the direction of the axis. Modes of this type are termed transverse electric or TE modes. In the other type of distribution, the situation with respect to the fields is reversed, the magnetic field being everywhere transverse to the guide axis while at some places the electric field has components in the axial direction. Modes of this type are termed transverse magnetic or TM modes. The different modes of each class are designated by double subscripts, such as TE_{10}. The particular mode will propagate down a waveguide with low attenuation only if the wavelength of the waves is less than some critical value determined by the dimensions and the geometry of the guide. If the wavelength is greater than this critical cutoff value, the waves in the waveguide die out very rapidly in amplitude even when the walls of the guide are of an infinite conducting material.

Different modes have different values of cutoff wavelength, the particular mode for which the cutoff wavelength is greatest is termed the dominant mode.

The behavior of a waveguide is similar in many respects to the behavior of a transmission line thus waves traveling along a guide have a phase velocity, and are attenuated. When a wave reaches the end of a guide it is reflected unless the load impedance is carefully adjusted to absorb the wave; also an irregularity in a waveguide produces reflection just as does an irregularity in a transmission line. Again, reflected waves can be eliminated by the use of an impedance matching system, exactly as with a transmission line. At ultra-high and microwave frequencies, waveguides provide a practical alternative to transmission lines for the transmission of electrical energy.

2) CHARACTERISTICS OF ELECTROMAGNETIC GUIDED WAVES IN TUNNELS :

The problem of guided wave propagation in a wave guide with imperfectly reflecting boundaries arises in several applications, such as propagation in mine tunnels and in screened surface wave guides. Electromagnetic wave propagation in road and mine tunnels has been a subject of interest in the last few years especially in relation to the design of mobile radio communication systems [1],