TRANSEQUATORIAL PROPAGATION ON VHF AND LOW UHF BANDS DURING THE PEAK OF SOLAR CYCLE 21 FOR THE EURO-AFRICAN SECTOR.

C.Fimerelis and N.K.Uzunoglu
Department of Electrical Engineering,National Technical University of Athens,Athens 147,Greece.

1. Introduction

Propagation over transequatorial paths has been observed for the first time in 1947 by Tilton(1) for a circuit path between Mexico and Argentine. In the following 32 years the propagation over transequatorial(TEP) paths has been studied extensively by many authors(2),(3),(4). In all of these previous TEP investigations the highest observed frequency for the Euro-African sector is 70MHz.

In this paper experimental TEP results are reported at higher frequencies such as 144MHz and 432MHz. In order to investigate the TEP phenomena on VHF and low UHF frequencies propagation between Athens(Greece) and Salisbury(Zimbabwe)-Pretoria(South Africa) has been studied. The used frequencies are 28,50,144 and 432MHz. Parameters such as circuit reliability,signal strength,Doppler frequency shifting,frequency spreading,flutter fading and absolute propagation time delay were measured and compared for various transmission frequencies in conjuction with the solar and geomagnetic activity. Several important conclusions are drawn for the explanation of TEP.

2. Experimental results

Transmission of beacon stations from Salisbury and from Pretoria are monitored in Athens. The transmission frequencies from Salisbury were 28,144 and 432MHz and from Pretoria 28,50 and 144MHz. In fig.1 the propagation paths for the used circuits are shown on a magnetic inclination map. In table 1 radiated RF power and antenna gains are summarized. Because of the observed low signal to noise ratio at 432 MHz,mainly the experimental observations are concentrated on 144MHz frequency. The radio beacons were transmitting synchronized RF pulses (approximately 1ms pulse width) in three working frequencies. Additionally the Pretoria beacon was synchronized on all working frequencies with the Universal time(UTC). A Loran C synchronization time pattern is employed for this purpose. The absolute propagation delay between Pretoria and Athens was measured by synchronizing the receiving station also with Loran C system of the Mediterranean Sea. The overall accuracy of time delay measurements were 0.1ms. All beacons were running every night between the critical hours 18:30 to 22:00 LMT from April 1978 up to the end of December 1980. During this period diurnal,seasonal and year to year variations of the signals were recorded. Short term signal statistics is also analysed such as Doppler frequency shift,path attenuation and fading rate. Off line analysis techniques are employed for spectral analysis of the received signals.

3. Experimental results

After three years of contincus observations the general characteristics

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of TEP can be summarized as follows:

a) Propagation via ionosphere on TEP paths is observable up to the frequency of 432MHz. The probability of having an "opening" is higher during the years of high solar activity.
b) The time duration of "openings" for higher RF frequencies tends to be smaller and the time of TEP "opening" is concentrated around the 20:00 LMT.
c) From communication channel viewpoint the high flutter fading and frequency spreading limits the usable channel bandwidth to a great extend. As a result of this only transmission of slow CW is intelligible.
d) The seasonal variation of circuit reliability is negatively correlated with high geomagnetic activity and the year to year variation is positively correlated with the solar flux.

In table 2 results are given for the path losses as compared to free space attenuation values for the corresponding distances. It is interesting to note that for 144MHz the average path loss is 56dB with a minimum value of 47dB below the free space attenuation. In fig.2 the mean and standard deviation values for the absolute time delays are given. A best fit curve for the mean time of the delay is shown to be:

$$T_d(\mathrm{ms})=22.4\ f^{0.03}(\mathrm{MHz})$$

The observed Doppler shifts at 144MHz are very characteristic and on the average are (-100Hz). The Doppler shifts are ranging from -350Hz to +40Hz. Digital Spectral analysis of recorded monochromatic CW transmissions shows interesting frequency spreading characteristics. One sample distribution is shown in fig.3. This shows the fast changing characteristic of the transmission medium.

From the measured propagation characteristics it is possible to draw some general conclusions for the TEP mechanism,

a) From the known fine structure of equatorial ionosphere(5) and the analysis of the TEP signal characteristics(Doppler shift, frequency spreading) it seems that the propagation is through a multiple scattering process from the inhomogeneities inside the F-layer.
b) Analysis of the observed absolute propagation delay data and the geometry of the paths shows that the scattering cannot be located in a single position over the magnetic equator.

4. Acknowledgments

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Transmitting Stations

	144MHz		432MHz	
	RF Power	Antenna Gain	RF Power	Antenna Gain
Pretoria	100W	21dBi	-------	-----
Salisbury	200W	14dBi	40W	17dBi

Receiving Station

	144MHz		432MHz	
	Noise Figure	Antenna Gain	Noise Figure	Antenna Gain
Athens	4dB	16dBi	3dB	21dBi

Table 1. Basic characteristics of the terminal stations.

Frequency(MHz)	Path loss(below free space attenuation)
28	10dB(mean value)
50	15dB(" " ")
144	47dB(minimum value)
432	61dB(" " " ")

Table 2. Path loss for a circuit between Athens-Salisbury(6260km)

Fig. 1. TEP path geometries.

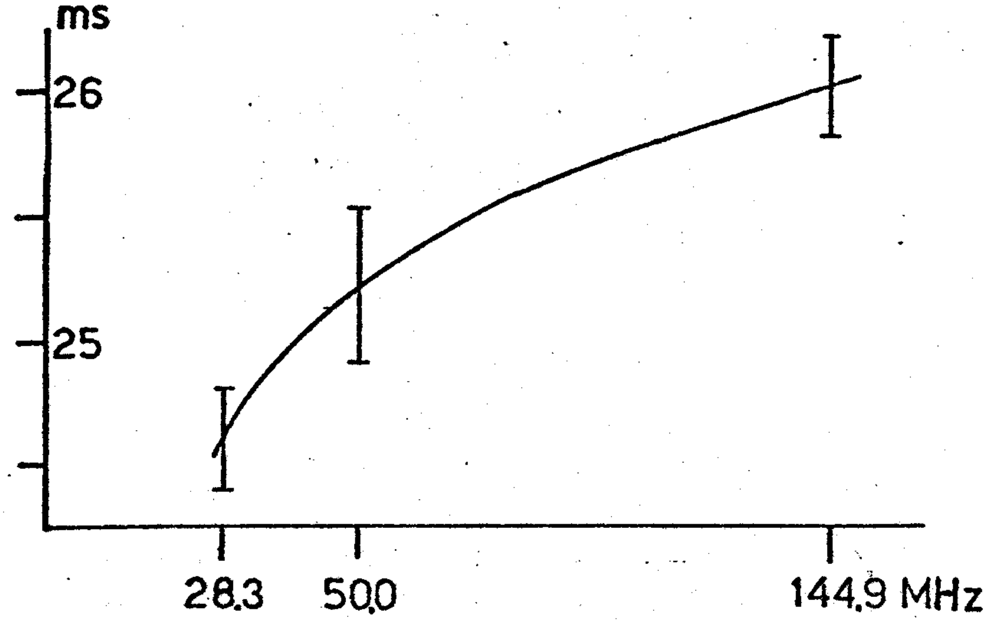

Fig. 2. Mean and standard deviation values of the absolute delay for a path Pretoria to Athens.

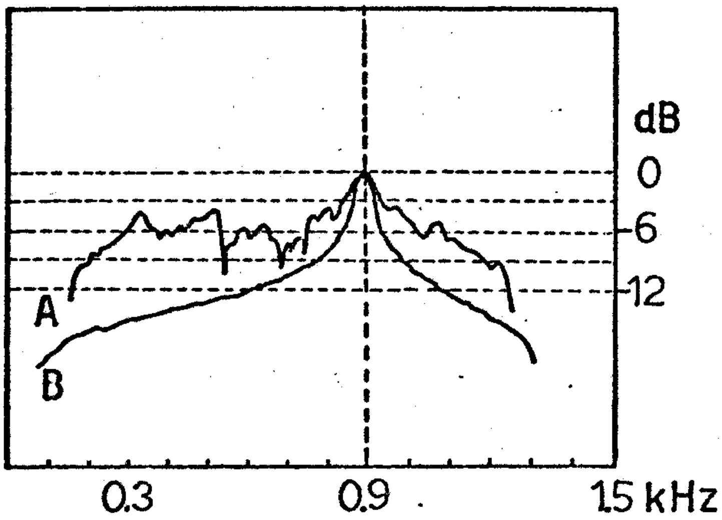

Fig. 3. Power spectrum distribution for (A) TEP signal at 144MHz and (B) Monochromatic CW signal.