RESEARCH ARTICLE OPEN ACCESS

Design and Experimental Investigation for Improving the High Frequency Radio Communication Links between Benghazi-Libya and Sfax-Tunisia.

Mohamed Yousef Ahmed Abou-Hussein*[1], Abdulsalam H. Ambarek[2]

* The Corresponding Author

[1]Department of Electrical and Computer Engineering, Al Garabuli - Faculty of Engineering, El Mergib-University, Khoms-Libya. Tel: 00218216621101/2 & Fax: 00218216621103.

[2]Department of Electrical and Electronic Engineering, Faculty of Engineering, Benghazi University, Benghazi-Libya.

ABSTRACT
In this study, we have experimentally planned to replicate the positive results of the application of ionospheric prediction method to design and improve the high frequency (HF) radio communication links between Benghazi-Libya and Sfax-Tunisia. The central radio propagation laboratory (CRPL) method of ionospheric prediction of the National Bureau of Standards (NBS) in U.S.A was used in the calculations of the optimal working frequencies for reliable HF radio communication links between Benghazi-Libya and Sfax-Tunisia. The results were drawn in the form of curves by using the computer. The computer was used to measure the received signal level variation of a frequency 17.500 Megahertz (MHz), which was transmitted with a power of 100 Kilowatt (KW) from the Tunis Republic Broadcasting station in SFAX city, directed to the east region. The measurements were taken during daytime's for winter (December, January& February) and summer (June, July & August) seasons.

Keywords; Design and Experimental Investigation, The optimal working frequency, Reliable HF radio communication links, the ionospheric prediction method, the National Bureau of Standards, the Central Radio Propagation Laboratory.

I. INTRODUCTION

The high frequency radio communication links involve the usage of a range of usable frequencies which include; the critical frequency, the Maximum usable frequency (MUF), the lowest usable frequency (LUF) and the frequency of optimal transmission (FOT) that needs to be predicted for operator use.

The Maximum usable frequency is the highest frequency that allows reliable long-range HF radio communication between two points by ionospheric refraction. Although from physical point of view, it is better to use as high frequency as possible to significantly reduce the strong increase of the absorption with decreasing frequency, however this is not practical, since MUF varies considerably from day to day, and it changes according to; solar activity, season, and time of day.

In practice, we have chosen the frequency of optimum transmission (FOT). FOT is also called the optimum working frequency or the optimum traffic frequency.

In this study, we have planned to replicate the experimentally driven hypothesis which is the following; the application of the central radio propagation laboratory (CRPL) method of ionospheric prediction of the National Bureau of Standards (NBS) in U.S.A in the calculations of the optimal working frequencies would significantly enhance the performance of reliable HF radio communication links between two points [1].

The FOT for reliable HF radio communications links between Benghazi-Libya and Sfax-Tunisia were determined by using the CRPL method of NBS [2]. The effects of the ionospheric variations on the performance of the short wave (HF wave), which transmitted with a frequency 17.500 MHz and a power of 100 KW [3] from the Tunis Republic Broadcasting station in Sfax city in Tunisia, directed to the east region [4] and they were received by the VLF - HF - Receiver EK 070 which operates on the frequency range from 10KHz to 30 MHz, with 20 dB(μv) threshold level, and with a class of emission A3(AM, double sideband with full carrier, bandwidth

= 6 KHz), with this class of emission its sensitivity < 2.0 μv [5]. This receiver is available at the communication laboratory- Engineering-Faculty-Benghazi University- Benghazi city-Libya.

This research includes measuring the variation of the signal level received during daytime's for the winter and the summer seasons of the Year by using the computer.

The study shows the decrease and the increase in the signal level received when its frequency near to or far from the predicted FOT (the Frequency of Optimum Transmission) of Benghazi-Libya and Sfax-Tunisia radio communications links.

II. THE CALCULATIONS OF THE OPTIMAL WORKING FREQUENCIES

The calculations relevant to the optimal working frequencies of the point to - point HF radio communication links between Benghazi-Libya and Sfax-Tunisia using the CRPL method of ionospheric prediction are taken. In those calculations; the Zurich monthly sunspot numbers for the periods of; (December, January, February, and June, July, August) were used [1] [6].

The results are shown in Tables I and are plotted in Fig.1.

LOCALTIME (hours)	Summer Season FOT * (MHz)	Winter Season FOT * (MHz)
00	2.7	2
02	2.7	2
04	6.4	2.1
06	11.8	6.4
08	13.8	10.9
10	14.5	12.2
12	14.3	11.9
14	13.8	10.9
16	11.8	6.4
18	6.4	3.3
20	4.5	2
22	3.2	2

Table I. The predicted FOT calculations of the Benghazi-Libya and Sfax-Tunisia link. FOT*= the Frequency of Optimum Transmission & MHz = Megahertz.

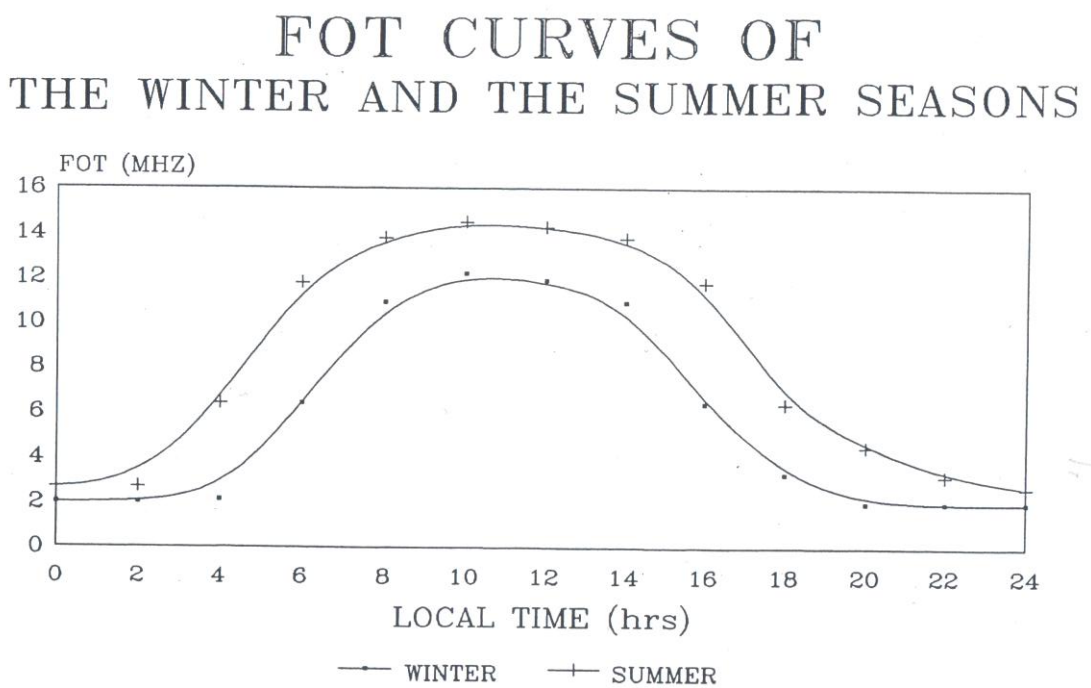

Fig1. FOT curve for Benghazi-Libya and Sfax-Tunisia link. FOT=Frequency of Optimal Transmission & MHz = Megahertz.

III. METHODOLOGY AND EXPERIMENTAL WORK DESCRIPTION

(1) The receiving antenna was designed as a horizontal wire multiple frequency dipoles antenna (multiband antenna) at the frequencies; 7, 15 and 21 MHz [1] [7].

The calculated physical resonant lengths for straight horizontal dipoles centred on the correspondent higher frequency bands [1].

The wires which were cut at the above resonant lengths and joined together at the common center which was connected by a single feed line (coaxial cable) to the VLF-HF-Receiver EK070. The dipoles were mounted horizontally on six masts beside the communication laboratory at the height 12 meters above the ground [1].

Fig. 2 shows the block diagram of the experimental set-up [1].

(2) The VLF-HF-Receiver EK070 was interfaced with IBM personal computer by using the interface-bus system IEEE-488. The IEEE-488 bus system will only permit the remote control and data call-up of the receiver by the computer (Controller). This bus system was designed in the communication laboratory [1].

(3) The measurement and recording of the signal level variations was conducted and achieved by using 8088 assembly language program [1].

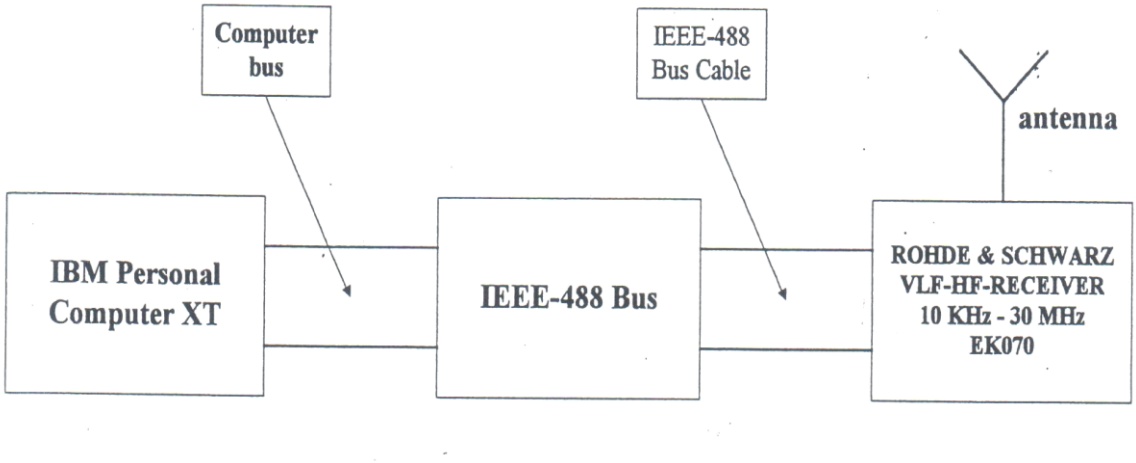

Fig 2. The block diagram of the experimental setup.

The signals were received by the receiver. Each' even .two hours, the computer read the data of the signals levels which their frequencies were understudy and equal to; 17:500 MHz. The computer gave the output on the screen. These data were recorded and stored in the hard disc of the computer.

The recorded data were printed on a copy by the printer after some interval of times (from three to seven days).

Fig.3 shows the block diagram of VLF - HF - Receiver EK070 and the output where measurements are taken [1].

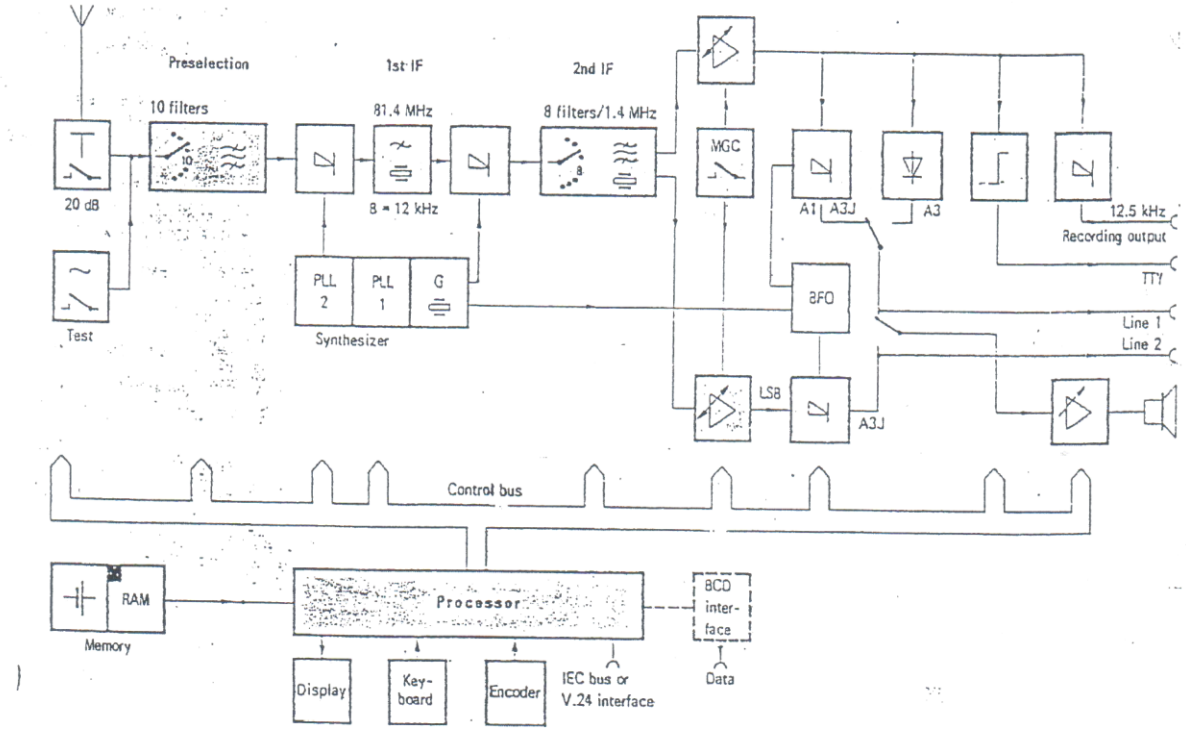

Fig.3. the Block diagram of VLF - HFReceiverEK070 with Microprocessor Control.

These records were made at a time interval of even two hours each. The two hours intervals were used to follow up the significant variations of the ionosphere, which affect the signal level of the propagated HF wave within and through it [1].

IV. EXPERIMENTAL RESULTS

The data were recorded during the winter and the summer seasons of the year at the time interval (08 - 16 hrs) at which the Tunis Republic broadcasting short wave working at the frequencies 17.5 MHz [3].

The results are presented in Table II and are plotted in Fig. 4.

Local Time (Hours)	**Summer Season**				**Winter Season**			
	Signal Level [dB* (µv**)]				Signal Level [dB* (µv**)]			
	June	July	August	**Median Value**	December	January	February	**Median Value**
00								
02								
04								
06								
08	30	30	50	**30**	65	50	40	**50**
10	20	35	35	**35**	50	55	65	**55**
12	20	35	35	**35**	40	65	55	**55**
14	20	20	20	**20**	40	45	50	**45**
16	15	30	15	**15**	30	25	50	**30**
18								
20								
22								

Table II. The signal level measurements of the received short wave with a frequency 17.5 MHz at Benghazi city-Libya. * dB=Decibel & ** µv=microvolts.

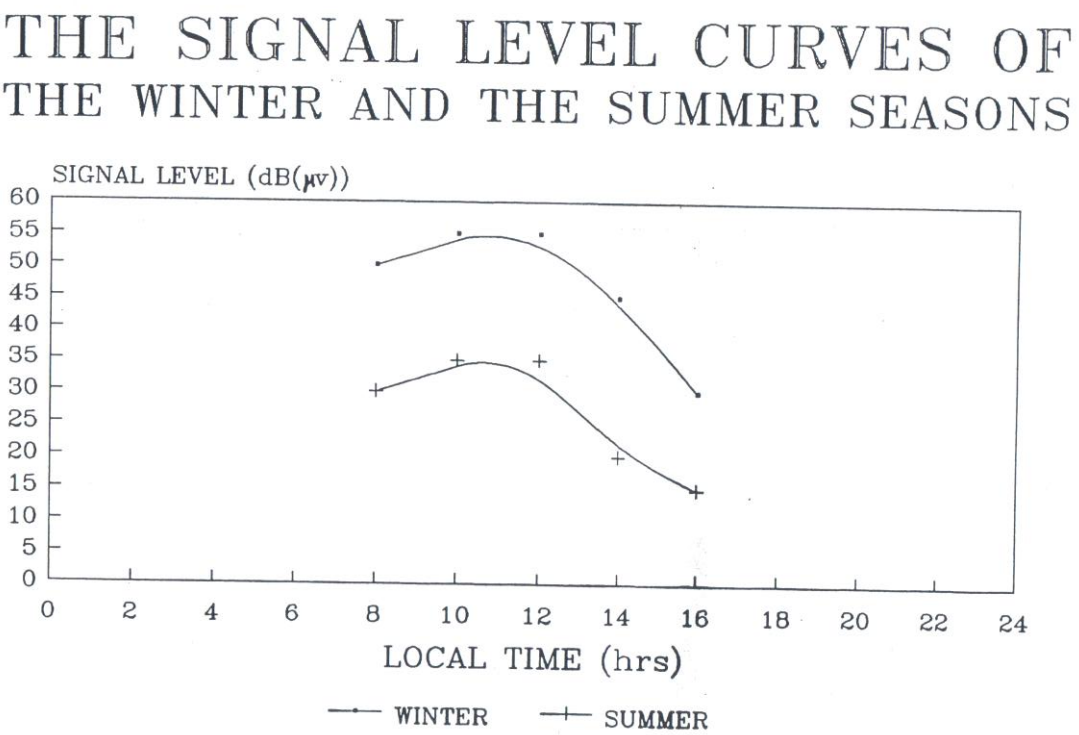

Fig 4. Median values of the signal level measurements of the received short waves with a frequency 17.5 Megahertz (MHz) at Benghazi city-Libya.

V. DISCUSSION

In this study, the experimental work demonstrated that: the received signal level decreased and consequently the attenuation increased as the span between the operating frequency and the predicted FOT increased.

Furthermore, although the data showed that when the received signal-level reduced, the received message was low and when the received signal level increased, the received message was high, however, the results demonstrated also a very significant finding which is that; when the operating frequency has approached the predicted FOT, the level of the received signal increased and consequently the attenuation reduced.

In addition to that, the final outcome results showed also that in summer season, the attenuation of the received signal leve1 is greater than that in the winter season.

VI. CONCLUSION AND RECOMMENDATION

This study has successfully replicated the experimentally driven hypothesis that the application of the central radio propagation laboratory (CRPL) method of ionospheric prediction of the National Bureau of Standards (NBS) in U.S.A in the calculations of the optimal working frequencies would significantly enhance the performance of reliable HF radio communication links between two points.

The two points in this research work are; Sfax-Tunisia as transmitting point and Benghazi-Libya as the receiving point.

Furthermore, the final results show that; It would be recommended to change the frequency 17.5 MHz of the transmitted signal of the Tunis Republic broadcasting station with a power 100 KW, directed to the east region**,** according to the predicted FOT values of Table I, during the time Interval (14 - 16 hrs) in order to obtain the high signal level at the receiving region and consequently high quality service (sound) is received. It is also advisable to maintain the current operating frequencies during the time interval (08 - 12 hrs) at which the signal level is already of high quality.

ACKNOWLEDGMENT

Our acknowledgements and sincere thanks are due to; Eng. Ali Elbdri for his kind assistance and help throughout the preparation of this work. Our acknowledgements are due also to Eng. Farag M. Sallabi and Eng. Mutaz T. Omran for their kind assistance in typing this paper. We are also very grateful and highly acknowledging the support of the Scientific Association of Electrical and Electronic Engineering (Benghazi - Libya) specifically Eng. Hussain A. Alhadad and Eng. Ahmed Almehdawi for their kind assistance during the performance of this paper.

.

REFERENCES

[1] Mohamed Yousef Ahmed Abou-Hussein, Abdulsalam H. Ambarek. Experimental Investigation Related To Some Predicted Results Of Reliable High Frequency Radio Communication Links Between Benghazi-Libya And Cairo-Egypt. *Int. Journal of Engineering Research and Applications*, *Vol. 4, Issue 1(Version 4),* 2014, 21-28.

[2] A. Picquenard, "*Radio Wave Propagation*", (John Wiely & Sons, Inc., New York, USA, 1997).

[3] P. Shore, "*International Radio Stations Guide*" Bernard Babani (Publishing) Ltd., London, England, 2000.

[4] *The Tunis Republic Broadcasting Announcement*, 2004.

[5] *VLF - HF - Receiver EK070 Manual*, (Rohde & Schwarz GMbh Co., Germany, 1992).

[6] *Sky & Telescope Magazine*, Vol. 81, 110. 5 , pp. 436, no. 6, pp. 561 , no. 7 , pp. 621 , Vol. 82 ,no. 5 , pp. 563 ,no. G, pp. 371, no. 7, pp. 456, (Sky Publishing Corporation, Massachusetts, USA, 2002).

[7] *Radio Communication Hand book*, (Radio Society of Great Britain, London, England, 1999).