Study the orientation and distance factors effects on the lower usable frequency (LUF) over middle east region

Khalid A. Hadi, Aqeel Z. Aziz

Department of Astronomy and Space, College of Science, University of Baghdad, Baghdad, Iraq

dr.khalidiq@yahoo.com, aqeel_a88@yahoo.com

Abstract

In this research, the influence of the orientation and distance factors on the lowest usable frequency (LUF) parameter has been studied theoretically. The calculations of the (LUF) parameter have been made using the (VOACAP) international communication model for the connection links between the capital Baghdad and many other locations that distributed on different distances and directions over the Middle East region. The results shown in this study indicate there is a slight affection of the link direction (orientation) on the LUF parameter, while the influence of the distance factor is more significant on the values of the LUF parameter. The day/night effect appears for the long distance HF links (i.e. more than a 500 Km)

Key words

Radio Wave Propagation, LUF, Lowest Usable Frequency, HF-Models.

Article info

Received: Feb. 2012
Accepted: Jun. 2012
Published: Oct. 2012

دراسة تأثير عاملي الأتجاه والمسافة على قيم الترددات الدنيا المستخدمة (LUF) فوق منطقة الشرق الأوسط

خالد عبد الكريم هادي، عقيل زهير عزيز

قسم الفلك والفضاء ، كلية العلوم ، جامعة بغداد ، بغداد ، العراق

الخلاصـــــــة

تم في هذا البحث إجراء دراسة نظرية لحساب تأثير عاملي الاتجاه والمسافة على معامل أدنى تردد مستخدم للاتصالات بعيدة المدى (LUF). حيث تم استخدام نموذج الاتصالات العالمي (VOACAP) لحساب قيم معامل الـ (LUF) لروابط الاتصالات الواقعة بين العاصمة بغداد والعديد من المواقع الموزعة على مسافات واتجاهات مختلفة ضمن حدود منطقة الشرق الأوسط. أشارت نتائج هذه الدراسة أن هناك تأثير طفيف لاتجاه وصلة الأتصال (معامل الاتجاه) على قيم معامل التردد الأدنى LUF، في حين أن تأثير عامل المسافة قد أعطى تأثير أكبر على قيم معامل الـ LUF. كما أوضحت الدراسة أيضاً أن تأثير تغاير النهار/الليل قد ظهر بشكل أوضح على وصلات الاتصالات بعيدة المدى (أي الأكثر من 500 كيلومتر).

Introduction

In the late '30s, many organizations were involved in the study of HF communications to investigate ionosphere parameters and determine their effect on radio waves and the associated reliability of HF circuits [1]**.** The lowest usable frequency (LUF) is the lower frequency that allows reliable long-range HF radio communication between two points by ionospheric refraction [2]. Many studied has been made to predicted lowest usable frequencies for HF band like Trifunac (1978), Joyner and Boore (1982), Sabetta and Pugliese (1996), Campbell (1997), Zhao et al. (2006), Danciu and Tselentis (2007), Boore and Atkinson (2008), Bindi (2010) and John Douglas and David M. Boore (2011)[3].

The accepted working LUF is the lower frequency predicted to occur via a normal reflection from the F2-layer (F-region at night) on 10 percent of the days of the month at a given time of day on a specified path. The LUF that can be refracted depends on the properties of ionosphere layer and the horizontal length of the hop, so the LUF changes with the time of day, season, geographic location, and solar activity. During maximum solar activity the LUF can rise to higher HF band during daylight hours, while during minimum solar activity the LUF can be at or below the lower part of the HF band [4].

Radio waves propagation

Radio propagation is the behavior of radio waves when they are transmitted or propagated from one point on the Earth to another or into various parts of the atmosphere.

The ionosphere is a particularly important region with regards to radio signal propagation and radio communications in general. It is defined as that portion of the earth’s atmosphere above 70 km where ions and electrons are present in quantities sufficient to affect the propagation of radio waves.Its properties govern the ways in which radio communications, particularly in the HF radio communications bands take place [5].

The normal mode of radio wave propagation in the HF range is by refraction using the ionospheric layers for single hop and by a combination of reflection and refraction between the ground and the ionospheric layer for multiple hops [6].

Some of the HF signals which leave the Earth's surface will travel toward the ionosphere and reflected back to Earth. This radio signal communication method is termed “sky waves propagation method”, for example LUF is returned to the Earth, and then the ionosphere may be viewed as a vast reflecting surface encompassing the Earth that enables signals to travel over much greater distances than would otherwise be possible [7], as shown in Fig,1.

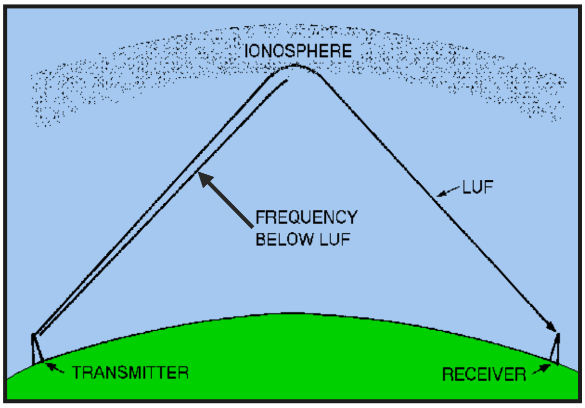

Fig. 1:- Illustrates the propagation of sky waves[8].

HF communications have been widely used for nearly 100 years to provide communications to long distances and remote areas via the ionosphere.

Many HF communication models for the short-wave band have been performed since the end of the 1930’s. In this decade the impact of the ionospheric radio propagation was discovered to measure ionospheric parameters. In the late 1970s/early 1980s many HF technologies were developed to show the HF system characteristics in the ionospheric layer.

Radio communication Working Party 9C dealing with fixed service systems below about (2-30) MHz, decided early in 1997 to establish a group for preparation of a HF programs. The decision was taken in anticipation of the World Radio communication Conference (Geneva, 1997) (WRC-97) that made provisions to facilitate the use of frequency adaptive technology in these bands and mainly responding to the strong expression of interest on the part of the ITU Development Sector (ITU-D), which requested more detailed information than material already available in recommendations ITU-R[9].

Currently, the recommendation ITU-R could be developed many new computer programs to predicts the monthly median LUF parameter, like ICEPAC [10], REC533 [11], and VOACAP [12].

International communication model (VOACAP)

In the present work, the Voice of America Ionospheric Communications Analysis and Prediction model (VOACAP) have been adopted an HF communication performance analysis model.

The VOACAP model is developed by Voice of America (VOA) beginning with the 1983 version of IONCAP. VOA then funded the Naval Research Laboratory (NRL) to make specific changes to

in April 1993 and distributed to participants at IES (Ionospheric Effects Symposium May 1993) in Alexandria, Virginia. Simultaneous to funding NRL to enhance the mode.

The VOACAP computed detailed the IONCAP methodology, and renamed it to VOACAP so as to avoid confusion.

That version of VOACAP was completed for many parameters such as: SNR; Reliability; Required power gain; Signal power; MUF; LUF; FOT Takeoff/Arrival Angle and more [11].

Calculations and Results

In this project the VOACAP model has been adopted to calculate the LUF parameter between transmitting and receiving stations over Middle East Region because this model represents one of most modern recommended HF communication models beside this model has been adopted by many international broadcasting stations like British Broadcasting Corporation (BBC), Voice Of America Radio (VOA) and others.

The year 2000 had been selected, because it represents the peak of the 23 solar cycles.

The capital Baghdad has been represented as the transmitting station, while the other sixteen different locations which are distributed over Middle East Region represented as the receiving stations, as shown in Fig.2.

Fig. 2: The locations of transmitting, and receiving stations.

The geographic location (longitude and latitude) and distance between transmitting and receiving stations for the selected receiving satiations have been listed in Table1.

Table (1):- Illustrate the geographic locations and distance between transmitter and receiving stations: Where N=North; E=East; S=South; W=West.

	Name	Longitude (Degree)	Latitude (Degree)	Distance (km)
N	Turkey	44.38	37.85	500
	Georgia		42.36	1000
	Russia		46.86	1500
	Russia		51.37	2000
E	Iran	49.80	3.35	500
	Iran	55.25		1000
	Afghanistan	60.68		1500
	Afghanistan	66.11		2000
S	Saudi Arabia	44.38	28.85	500
	Saudi Arabia		24.34	1000
	Saudi Arabia		19.84	1500
	Yemen		15.3	2000
W	Iraq	38.94	3.35	500
	*Med Sea	33.51		1000
	Med. Sea*	28.00		1500
	*Med. Sea	22.64		2000

*Med. Sea=Mediterranean Sea

Table2 shows a calculation sample of the LUF parameter by executing the VOACAP international model for the 2000 Km around the capital Baghdad for the link (Baghdad-Russia).

Table 2:- The sample of the results of LUF parameter for 2000 Km.

LUF Parameter (Baghdad – Russia) (MHz)												
Time	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
1	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
2	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
3	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
4	2.0	2.0	2.0	2.0	2.0	2.6	2.0	2.0	2.0	2.0	2.0	2.0
5	2.0	2.4	2.0	2.0	3.1	3.5	3.4	2.6	2.0	2.0	2.5	2.0
6	2.6	3.1	3.9	3.5	3.9	4.0	4.0	3.9	3.2	3.7	3.2	2.5
7	3.4	4.7	5.7	3.9	4.1	4.0	4.0	4.1	6.0	5.4	4.0	3.3
8	5.3	6.0	7.5	8.3	4.1	6.1	6.2	9.4	8.2	6.8	6.1	4.6
9	7.0	8.2	9.9	11.6	14.2	13.1	13.6	12.4	11.0	8.6	8.0	6.8
10	8.5	10.3	12.2	13.3	16.5	13.5	14.3	14.0	15.6	10.6	9.2	8.0
11	10.3	12.4	14.8	13.8	14.0	13.8	14.7	14.7	14.4	12.7	10.9	9.7
12	10.9	13.3	14.9	14.5	14.4	14.1	14.9	15.0	14.7	13.5	11.6	10.4
13	10.5	12.7	14.6	14.1	14.2	14.0	15.0	14.7	14.0	12.6	11.0	10.0
14	8.9	10.9	13.2	13.0	13.3	13.5	14.7	13.6	12.2	9.9	9.6	8.3
15	7.2	8.7	10.3	11.2	12.0	12.3	13.5	12.0	9.5	8.4	7.7	6.2
16	6.0	7.1	8.6	9.3	4.1	6.1	6.4	4.0	8.2	6.9	6.3	4.6
17	4.0	5.7	3.9	4.1	3.9	4.1	4.0	3.8	3.9	5.7	4.2	4.1
18	3.6	3.9	3.5	4.0	3.9	4.0	4.1	4.2	3.5	4.0	3.8	3.3
19	2.8	3.4	2.0	3.2	4.0	3.9	3.9	3.9	2.0	3.5	3.1	2.5
20	2.0	2.7	2.0	2.0	2.0	3.7	2.0	2.0	2.0	3.0	2.0	2.0
21	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
22	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
23	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0

In this research, the affection variation of the orientation and distance factors have been studied on the LUF parameter, so each factor has been studied separately.

The first part conducted the study of the affection of orientation factor on the LUF parameter. For this reason sixty different receiving stations have been picked up that located on four directions around the transmitting station.

Fig.3, shows the results of the affection of the LUF parameter on the East, West, North**,** and South directions respectively of the studied area at a certain distances (500, 1000, 1500, 2000) Km from the transmitting station (Baghdad).

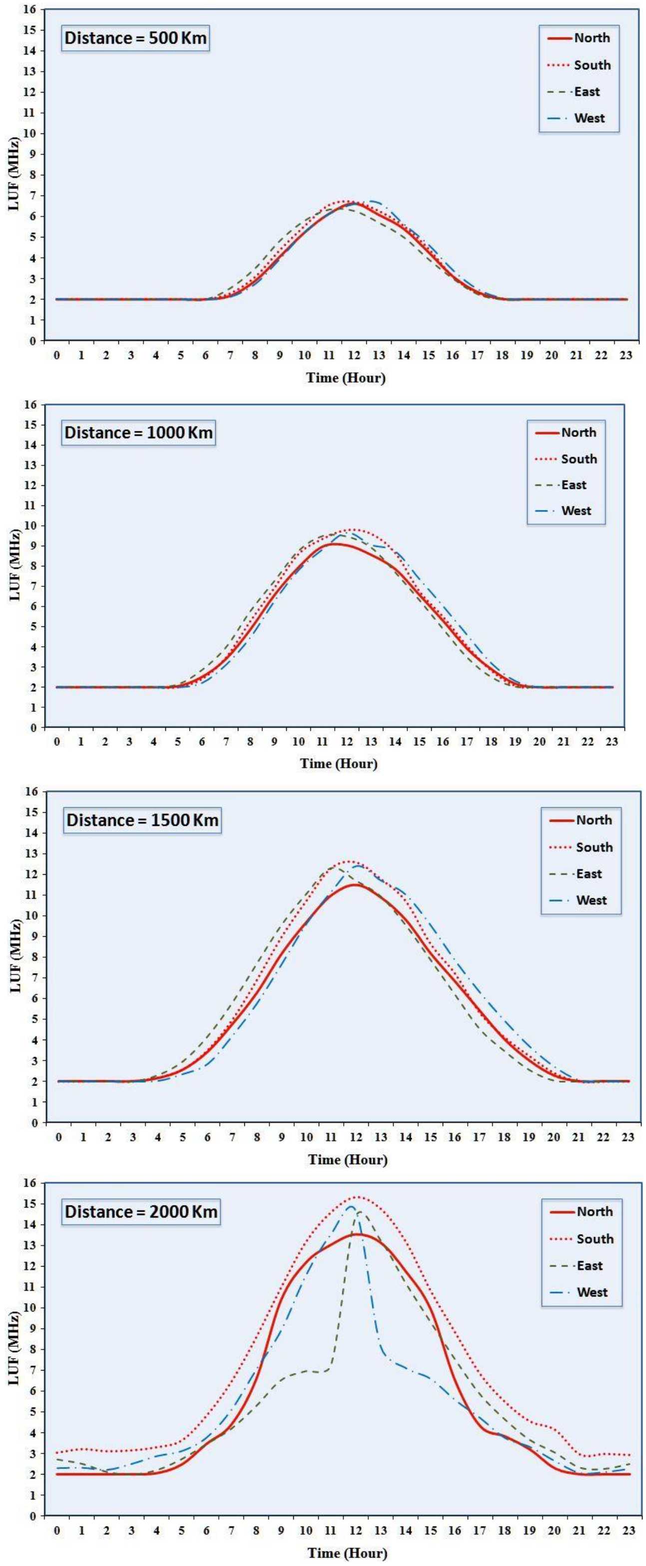

Fig.3:- The influence of orientation factor on the LUF parameter.

In the second part of this research, the affection of the distance factor for the distances of (500, 1000, 1500, 2000) km on the LUF parameter have been studied for the the four directions. Figure (4), illustrate the variation of the distance factor on the LUF values for each direction.

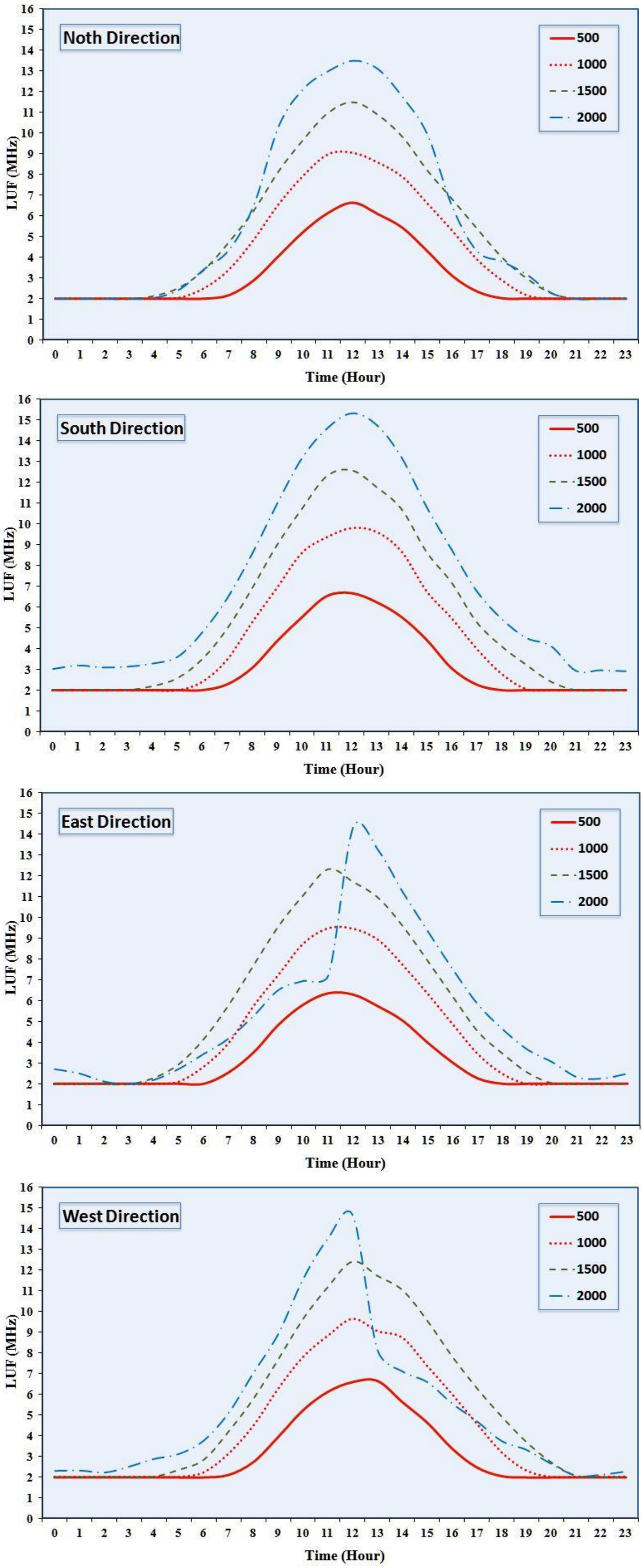

Fig.4:- The influence of distance factor on LUF parameter.

The investigation of the affection of the orientation and distance factors on the behavior of LUF parameter has been made for the dataset that have been got from the execution of VOACAP international communication model over Middle East Region.

The orientation factor effect has been studied for different sites which are located on different directions. The results of this study shows that the LUF parameter values for the North direction is differ from the South direction and the LUF values for East direction is differ from the West direction. This may be due to the variation of daily solar activity, that shown in Fig.3.

The affection of the distance factor on the LUF parameter values has been made for different distances (500, 1000, 1500, 2000) Km from the transmitting station (Baghdad). The results of this study, shows a variation of the LUF parameter for the tested receiving locations especially for long range distance. This variation may be due to the difference of geographic locations (longitude and latitude) and the sunrise and sunset time, that shown in Fig.4.

From the above discussion of the results of the LUF parameter for the studied region, it can be concluded that the behavior of LUF parameter can be slightly affected by the orientation factor while the affection of the distance factor shows a more complicated variation than that of the orientation factor, practically for these in the East and West locations.

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