Radio Contact Establishment Out of Iraqi Boarder using Nicosia Ionosonde Real data

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Abstract- *Although the advanced technology in satellites and optical fiber communication systems exists now a day, but the researches in HF sky wave propagation for Mesopotamia (Iraq) area is suffered from shortage. In this paper, the novelty is that the communication path from Baghdad to any distance out of Iraqi border had been predicted, calculated and measured experimentally by using real data (Ionogram) supplemented by Nicosia Ionosound station 1000Km from Baghdad and a radio station model TS-130SE as a transmitter. The Predicted results generated by using MATLAB and NTIA/ITS software package like VOACAP. Radio communication using TS-130SE with 36 countries had been done experimentally. A comparison between the theoretical and experimental results was done. The experimental results were in the range of the predicated results which emphasis proposed method Presented in this paper.*

***Index Terms*—FOT, MUF, NTIA/ITS software package, Nicosia Ionosonde station, radio distance calculation.**

I. Introduction

Electromagnetic waves of the band 3-30 MHz can travel long distances from the transmitter about 100 km, this reflection is due to ionosphere layers and sometimes can reach the other side of the earth [1]. There is a correlation between the sun activity and the HF wave propagation. The sun produces the ionosphere layers that made the radio signals to reflect from the layers and reach long distances. The layers performance is not constant, it is dynamic as it depends on solar activity [1,2].Now days communication services that offered by satellites are good and do not affected by ionosphere , but radio communication using shortwave band still has great use for long range communication and could be the second back up for communication because of simplicity and low cost of operations which is suitable for expeditions and military. HF used also on emergency relief communication when the communication infrastructures are gone by flood like what happened in Netherlands during 1953, New Orleans during 2005 and the tsunami disaster in Japan during 2011 [3]. The modern communication applications need new frequency channels, the spectrum is full, so the analogue channels on HF bands must be reused and the need for good prediction software for shortwave propagation is increased [4]. Although of the advantages using HF radio Waves, the performance of these signals effected directly by the ionosphere conditions and sun activity. Many software methods used to predict ionosphere variables which classified in groups such that Statistical, empirical and numerical software methods. The most widely used statistical method is Voice of America and Ionospheric Communication Enhanced Profile Analysis and Circuit Prediction Program (VOACAP) [5, 6, 7, 8,

9, 10, 11]. The novelty of this paper is to use real data variables such as f_0f_2 (the critical frequency of the F_2 layer of the ionosphere) and $h'f_2$ (virtual height of F_2 layer) supplemented by Nicosia Ionosonde station (35.1856° N, 33.3823° E) 1000 km away from Baghdad and using sets of empirical equations implemented by MATLAB to generate the values for a single hope information parameters like MUF (Maximum Usable Frequency),FOT (Operating Frequency) and d (the radio range distance) then compare the theoretical results by using VOACAP to predict MUF and coverage area in which Baghdad station is the transmitter. For final the theoretical results will being checked by experiments using a dipole on 20m band raised 10m above ground with main lobe beaming toward North-South of Baghdad (33.3128° N, 44.3615° E) and a transceiver of 100w from Kenwood model TS-130SE as transmitter .

II. Sky Wave Single Hope Geometry

Sky waves had big effort for DX communication (long rang communication) because of its ability of reflection from ionosphere layers and this reflection depends on sun activities, the frequency used and incident angle. The area allocated between first hope of sky wave and farthest ground wave rang is called skip zone in which no communication occurred [11]. From Fig (1) radio distance (d) between two points can be calculated through the use of sky wave propagation geometry using the equations (1-3) [3, 13].

$$d = 2h/\tan\theta \quad (1)$$

$$MUF = fc/\cos\theta \quad (2)$$

$$FOT = (0.5 \text{ to } 0.8) * MUF \quad (3)$$

Where d is the radio distance between Baghdad station & B station, f_c critical frequency of the ionosphere layer F_2, h is the ionosphere layer altitude, θ is the radiation angle of the antenna pattern which is a function of antenna height, MUF is the max. Usable frequency and FOT is the optimum operating frequency.

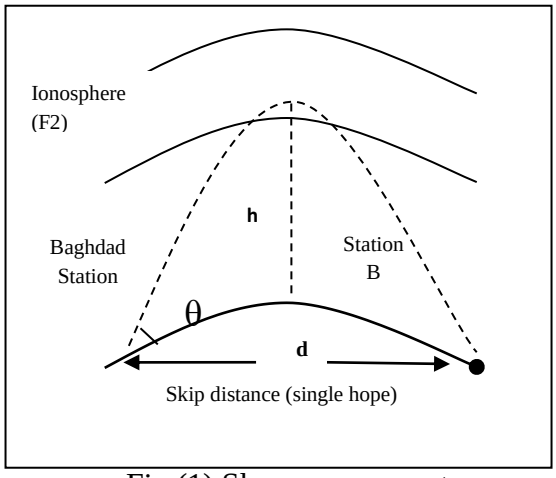

Fig (1) Sky wave geometry

III. Experiments and Results

In this paper a dipole antenna had been design using ITS HF software package on 20 m band with a center frequency was 14.2MHz because 20m band is active most of the day, each dipole arm of 5 m length and setup to a height of 10m above ground. The Radiation pattern and radiation angle of the antenna was shown in Figs (2-3).

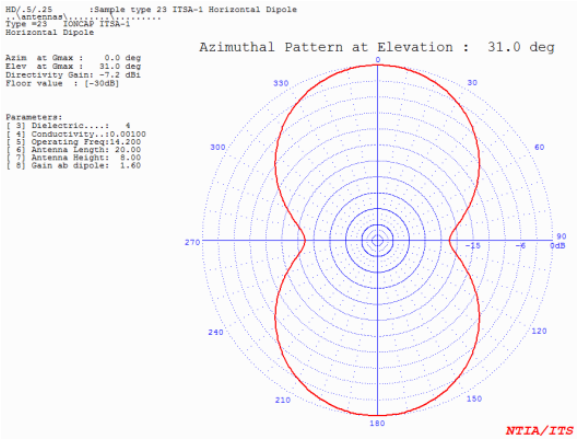

Fig (2) Antenna Azimuth

To find skip distance d (Θ) as function of radiation angle Θ, 10 deg to 60 deg were taken in which the antenna gain was 0 dB to -3dB as shown in points (1-3) of Fig (3). These values were given as

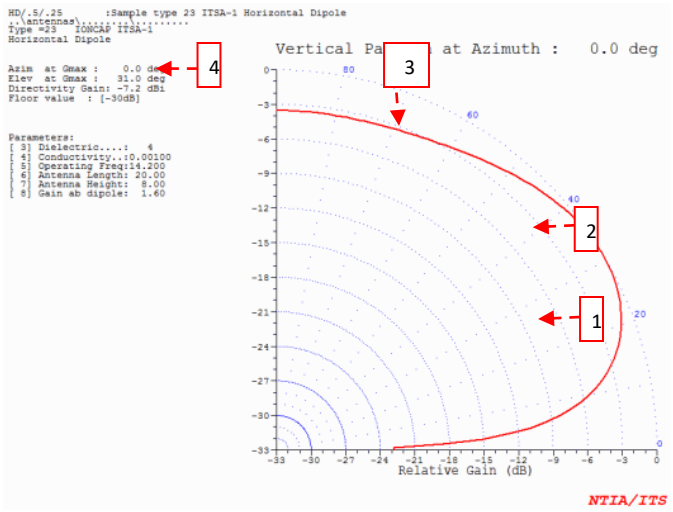

Fig (3) Antenna Elevation Angle Θ.

Input variables beside fof_2, $h'f_2$ instantaneous values (taken from Nicosia Ionogram) to the MATLAB simulation depended on questions (1-3). The MATLAB prediction was MUF vs. d, d vs. θ as shown in Figs (4-5). In this paper an assumption had been taken that ionosphere spot above Iraq-Nicosia was the same and homogenous.

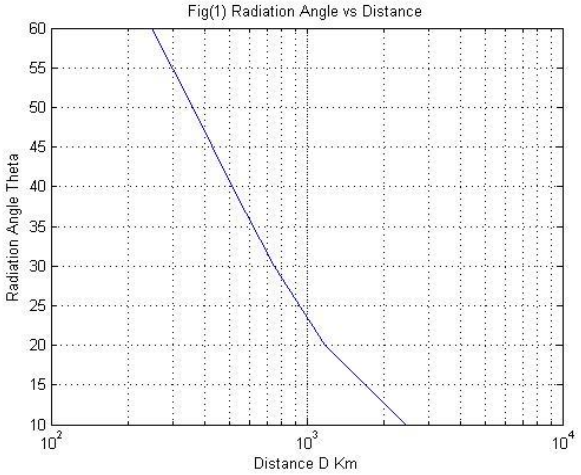

Fig (4) Radiation angle ΘVs. Distance d (Θ)

From Fig (4) the skip distance (single hope) was less than 300 km and coverage area was (300-1500) km approximately.

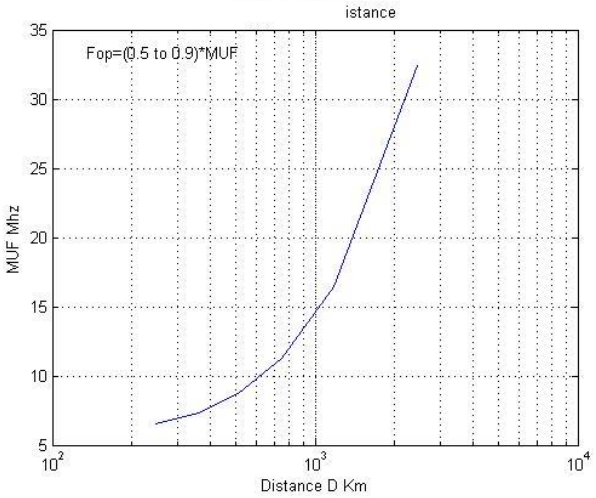

Fig (5) MUF vs. Distance d (Θ)

From Fig(6) Ionogram data that taken on 27 Jan 2017 of Nicosia Ionosonde station, f_of_2=5.625MHz, $h'f_2$=215Km variables used by MATLAB to simulate d(Θ) , MUF(d) as shown in Figs(4-5) ,the operating frequency FOT can be calculated for each MUF value by using equation (3)[3]. Also MUF values and skip distance found by using ITS HF package which is VOACAPAREA as shown in Fig (7). Finally experiments had been done on the same date by using Kenwood Radio Transceiver model TS-130SE as shown in Figs (8-9) with 100w RF power, SSB modulation Using the dipole as shown

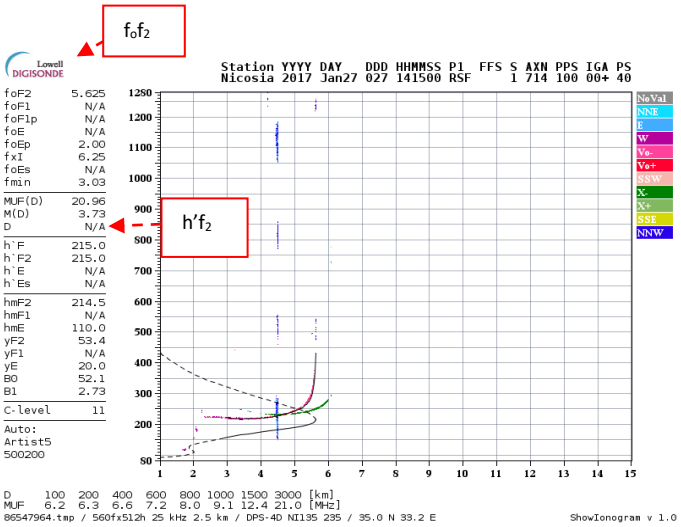

Fig (6) Nicosia Ionogram Data

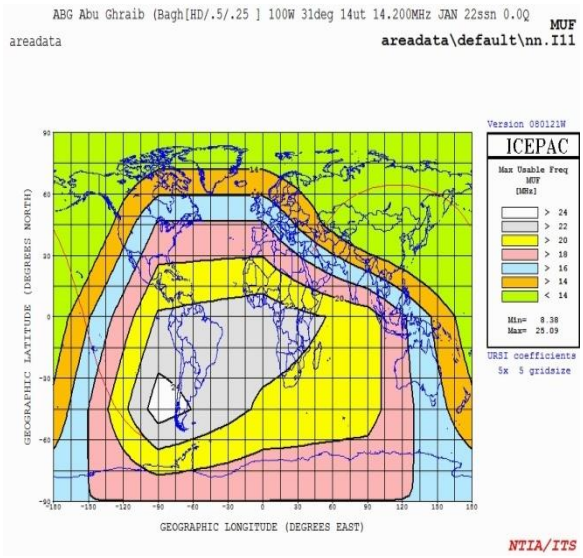

Fig (7) VOACAPAREA simulation

In Figs (2-3).Table (1) shows sample of the destination stations that had been received the Baghdad station signal on 27 Jan 2017.

VI. Discussion and Conclusion

1-In this paper , radio contacts experiments had been done with 36 countries on a frequency of 14.21MHz (FOT) from 1420 to 1531 UTC on Friday 27 January 2017 , samples were taken and Summarized as shown in Table (1).Comparisons were done with the previous simulations as shown in Table (2) and finally FOT selected was within the range previously calculated.

Fig (8) Kenwood TS-130SE

Fig (9) S-meter scale

Table (1) samples of practical radio contacts data between Baghdad and station B on 27 January 2017 at 14.21MHz

Received Station	Location		Distance from station A(Baghdad) Km	Time (UTC)
	Long.	Lat.		
Netherlands	**51° 33' 9'' N**	**5° 6' 45'' E**	3648	1447
Bulgaria	**42° 40' 56'' N**	**23° 20' 42'' E**	1929	1451
Romania	**47° 56' 12'' N**	**25° 42' 24'' E**	2086	1515

2-As shown in Table (2), variation in FOT calculations intervals caused by in real the ionosphere spot between Iraq and Nicosia is not the same, non homogenous distribution of electron densities and there is a time difference of about one hour between them, those differences effect of f_0f_2, $h'f_2$ and MUF measurements.

Table (2) FOT calculations using different MUF values

MUF calculated by	FOT interval	
	Min.(MHz)	Max.(MHz)
VOACAPAREA	8	14.4
MATLAB	13.5	24.3
Nicosia Ionogram	10.5	18.9

3- If intersection had been done between the three frequency intervals of Table (2), high probability of FOT will be 13.5MHz to 14.4MHz so FOT tested (14.21MHz) was within the intersected interval.

4- From Table (1) the communication path between Baghdad station and any station B was done using multi-hopes.

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