International Journal of Modern Electronics and Communication Engineering (IJMECE) ISSN: 2321-2152
Volume No. - 8, Issue No. - 5, September, 2020

Performance Transmission Evaluation of Predicted Point-to Point High Frequency Radio Communications Range in Libya

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Abstract: In Libya, the predicted range of the point- to – point high frequency (HF) radio communications extends from 2 to about 19 MHz. The aim of this research is to evaluate the transmission's performance of the predicted range using some of its predicted results that are related to the optimum operating frequency (FOT) for Tripoli-Benghazi HF radio communication link as a case study. The experimental investigation is accomplished by using the computer to measure the received short (HF) signal level variations of the operating frequency 7.245 MHz. This was transmitted with a power of 500 kilowatt (KW) during the time interval (08-18) hours of the local day times for the winter (December, January, and February) and the summer (June, July, and August) seasons, from the Libya broadcasting station in Tripoli city- Libya, directed to Benghazi city-Libya. The predicted range results were interpreted in relation to the received short (HF) signal level altered measurements when using the tested operating frequency of 7.245 MHz close to or far from the predicted FOT. The Results: show that the highest measured level of the median values of the received short (HF) signal are; 75 Decibel (microvolts) [dB (µv)] at 16 hrs and 45 dB(µv) at 18 hrs in the winter and the summer seasons respectively using the operating frequency of 7.245 MHz which is very close to the predicted FOTs (about 7 MHz). Conclusion: A fairly high reliability transmission can be attained under ionospheric influence by using the predicted HF radio communication range in Libya which extends from 2 to about 19 MHz.

Keywords: Performance transmission evaluation, Experimental investigation of some predicted results of point-to-point HF radio communications range in Libya, Operating frequency, predicted optimum working frequency.

I. Introduction

By using the Central Radio Propagation Laboratory (CRPL) method of ionospheric prediction of National Bureau of Standards (NBS) in the USA, the point- to –point high frequency (HF) radio communications range in Libya which extends from 2 to about 19 Mega Hertz (MHz) was practically predicted [1].

The above mentioned range is limited by; the maximum usable frequency (MUF), the lowest usable frequency (LUF), as well as an optimum working frequency (FOT). The FOT is found to be above LUF, equal or close to MUF and it provides the optimum communications.

The aim of this research is to evaluate the transmission's performance of the resulted predicted range. This is achieved by using the experimental investigation of some results of the predicted range which are related to FOTs for Tripoli-Benghazi HF radio communications Link [1], which is taken as a case study.

A. Predicting Optimum Working Frequencies for Tripoli-Benghazi HF Radio Communications Link

The optimum working frequencies (FOTs) of Tripoli-Benghazi HF radio communications link were predicted during daytimes of the winter (December, January, and February) and the summer (June, July, and August) seasons, by using the CRPL method of ionospheric prediction of NBS in the USA [1]. These predicted FOTs will be considered as some predicted results of HF radio communications range in Libya that extends from 2 to about 19 MHz, and are plotted in Figure 1.

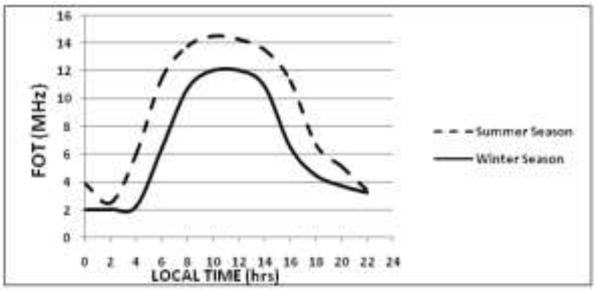

Figure 1. The predicted optimum working frequencies (FOTs) chart of the winter and the summer seasons for Tripoli-Benghazi HF radio communications Link, (hrs = hours, MHz = megahertz).

II. METHODOLOGY AND EXPERIMENTAL WORK DESCRIPTION

A. Experimental Work Description:

1. The receiving antenna was designed as a horizontal wire with multiple frequency dipoles antenna (multiband antenna) at the frequencies : 7 , 15 and 21 MHz [2], by using the following formula [3];

Total length in meters = $142.5/f_{MHz}$ …. (1)

The physical resonant lengths were calculated for straight horizontal dipoles centered on the higher frequency bands (Table 1).

Table 1. The Band frequencies (MHz) of the multiband antenna and their correspondents calculated physical resonant lengths (meters) for the straight horizontal dipoles.

Band (MHz)	Length (meter)
07	20.4
15	09.5
21	06.8

The wires were cut above the resonant lengths and joined together at the common center. The common center was connected by a single feed line(coaxial cable) to the VLF-HF-Receiver EK 070 which operates on the frequency range from 10 KHz to 30 MHz, with 20 Decible microvolts [dB(µv)] threshold level, and its sensitivity >2.0 µv[4] . This receiver is available at the communication laboratory – engineering faculty - Benghazi University - Benghazi City, Libya. The dipoles were mounted horizontally on six masts beside the communication laboratory at the height 12 meters above the ground [2].

2. The VLF-HF- Receiver EK070 was interfaced with IBM personal computer by using the interface bus system IEEE-488 [5]. 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 [6]. Figure 2 illustrates a block diagram of the experimental set-up.

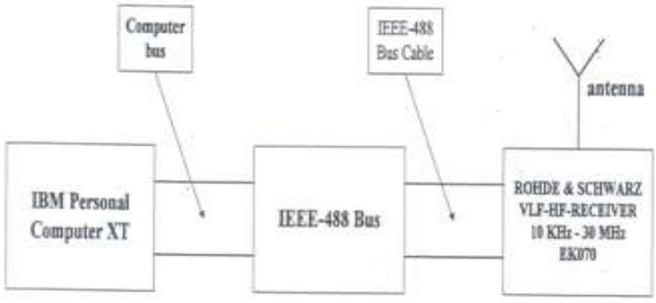

Figure 2. A block diagram of the experimental set-up.

B. The Received Short (HF) Signal Level Variations' Measurements and Recordings

The short (HF) signal with operating frequency of 7.245 MHz, was received by the mentioned earlier VLF-HF-Receiver EK070, each even two hours, the computer was interfaced with the receiver to read the data for the level variations of that received short (HF) signal, which was transmitted with a power of 500 kilowatt (KW) [7], during the time interval (08-18) hours of the local daytimes for the winter and the summer seasons, from the Libya broadcasting station in Tripoli City -Libya, directed to Benghazi City-Libya [8].

The computer gave the output on the screen. These data were recorded and stored in the hard disc of the computer. A copy of the recorded data was printed after some interval of times (from three to seven days). This was achieved by using 8088 assembly language program [5] [6], its flow chart is shown in figure 3.

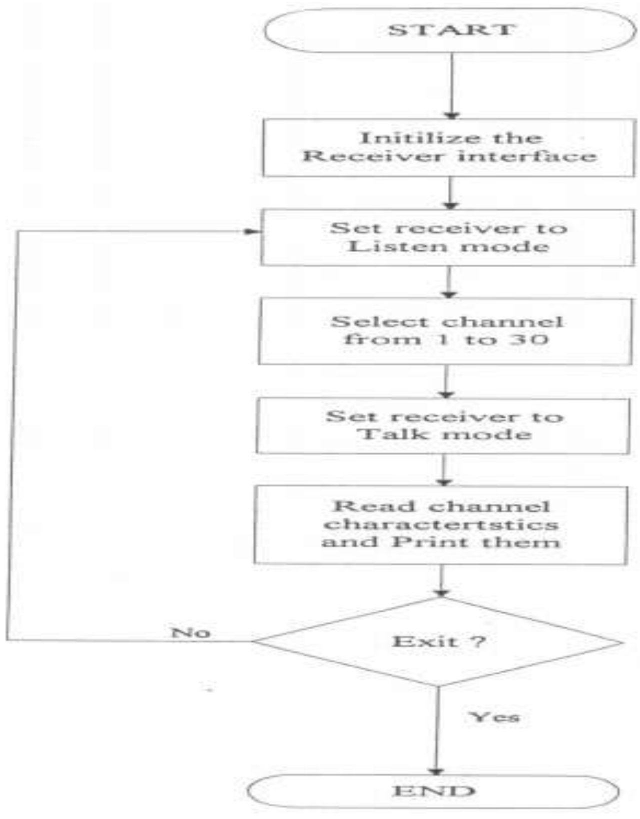

Figure 3. The measurements' flow chart of the received short (HF) signal level with its operating frequency of 7.245 MHz.

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 short (HF) signal within and through it [2].

III. EXPERIMENTAL RESULTS

The data were recorded during the winter and the summer seasons of the year at the time interval (08-18) hours of the local daytimes, at which the Libya Broadcasting short (HF) signal was working at the operating frequency 7.245 MHz [6]. The experimental results are plotted in Figure 4.

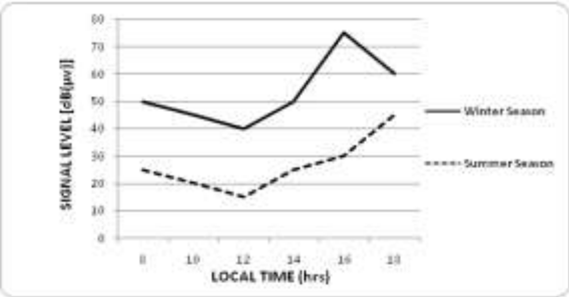

Figure 4. The median values of the received short (HF) signal level variations' measurements with an operating frequency 7.245 MHz at Benghazi City - Libya.

The results show also that the median value of the signal level [dB (μv)] is consistently higher in winter season than in summer season at all tested times. The differences range between; the lowest difference value of 15 dB which was registered at 6 PM (18 hrs) and the highest difference value of 45 dB which was registered at 4 PM (16 hrs) [Figure 4].

IV. DISCUSSION

The experimental work of this study has demonstrated the following:

- The highest measuring level of the median values of the received short (HF) signal are; 75 dB (μv) at 16 hrs and 45 dB (μv) at 18 hrs in the winter and in the summer seasons respectively, when the under studying operating frequency (7.245MHz) is very close to the predicted FOTs (about 7MHz).
- The highest measuring level of the median values of the received short (HF) signal at the mentioned measuring hours previously, is higher by 15 dB than the highest of the low measuring level median values which are 60 dB (μv) at 18 hrs and 30 dB(μv) at 16 hrs for the winter and the summer seasons respectively, when the understudying operating frequency (7.245MHz) is far from the predicted FOTs which are about 5MHz and about 11MHz for the winter and the summer seasons respectively.
- The lowest measuring level of the median values of the received short (HF) signal are; 40 dB (μv) and 15 dB (μv) at 12 hrs for both values in the winter and the summer seasons respectively, when the understudying operating frequency (7.245MHz) is the most far from the predicted FOTs which are 12MHz and about 14MHz in the winter and the summer seasons respectively.
- The measuring levels of the median values of the received short (HF) signal for the winter season are higher than of those for the summer season. This is because the ionization degree of the reflecting ionospheric layers which is related to the attenuation (energy loss) of that signal level during its transmission will be at the highest value in the summer season and at the lowest value in the winter season.

V. CONCLUSIONS

- The closer the understudying (investigated) operating frequency to the predicted optimum working frequency at a specific measuring hours, will enhance the received short (HF) signal level to its highest measuring median value. This will assure that the signal will suffer the least loss during radio transmission, and consequently the satisfactory reception will be obtained.
- The results clearly demonstrated that the highest measuring level median values of the received short (HF) signal was obtained when its understudying operating frequency is close to the predicted optimum working frequency. This is confirming that a fairly high reliability transmission can be attained under ionospheric influence by using the predicted HF radio communication range in Libya which extends from 2 to about 19 MHZ, for the successful operation in a practical approach over a different links of a various point-to-point HF radio communication systems.

VI. THE PERSPECTIVE RECOMMENDATIONS

- In order to achieve the optimal utilization of a various point-to-point HF radio communication systems under ionospheric influence in Libya, the operating frequency of any point-to-point HF radio communications link, has to be equal or close to the reliable predicted FOTs of the correspondent point-to-point HF radio communications range in Libya, which extends from 2 to about 19MHz.
- In general for the optimum results to be obtained, the predicted FOT values of the reliable predicted point-to-point HF radio communications range in Libya prove that, the variability of propagation conditions require frequent changes in the operating frequency which has to be equal or close to the predicted FOT values that vary with changing of the local daytimes.
- The study results point to the potential recommendation of the operating frequency of 7.245 MHz of the transmitted signal of the Libya broadcasting station with a power of 500 KW, directed to Benghazi- City Libya, preferably to be changed according to the predicted FOT values of the Figure 1, during time interval (08-14) hrs and at 18 hrs for the winter season, and during time interval (08-16) hrs for the summer season, to obtain on the highest received signal level. Furthermore, there is no need to change the operating frequency of 7.245 MHz at 16 hrs for the winter and at 18 hrs for the summer, at which the signal level will be at the highest value.

ACKNOWLEDGMENT

We would like to express our thanks to: Eng. Ali Elbdri, and to the scientific association of electrical and electronic engineering (Benghazi- Libya) specifically, Eng. Hussein A. Al Hadad and Eng. Ahmed Al Mehdawi, for their kind assistance.

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