Radiowave Propagation in GCC Countries: Measurement and Modeling

Pervez Z. Khan and **Asrar U. Sheikh**
†Center for Communications and Computer Research
∗Telecommunications Research Laboratory, Electrical Engineering Department
King Fahd University of Petroleum & Minerals Dhahran-31261, Saudi Arabia
(pzkhan, asrarhaq)@kfupm.edu.sa)

Abstract **— Intense temperature and high humidity has been the dominant factors that define the weather in the GCC countries for about six months of the year. Observations suggest that such weather has been the root cause of either breakdowns in communication links or extensions in the radio coverage. A comprehensive study of predicting field strength in presence of the weather in the frequencies between 30 MHz–3GHz has recently been completed. As a follow up to validate the developed propagation model, a campaign to measure the field strength has been launched. This paper describes the collection of the propagation date for a point-to-point link between Bahrain and Dhahran.**

Index Terms **— Radio waves, propagation, humidity, temperature, anomalous propagation.**

I. Introduction

It is well known that extreme temperatures and high humidity create conditions for anomalous radio propagation. The International Telecommunication Union publishes charts for refractive indices over different regions of the world. Unfortunately, such refractive index maps over the area covered by the GCC countries are not accurate enough to predict occurrence of anomalous propagation conditions. To fill this gap, a comprehensive study on the impact of weather on radio propagation was initiated under the patronage of GCC Telecommunication Bureau. The work is being conducted by the Research Institute of King Fahd University of Petroleum & Minerals (KFUPM), Dhahran, Saudi Arabia. The study is subdivided into two phases; the first phase pertains to the development of the theoretical basis for predicting the impact of weather on radio propagation. The work on the development of the propagation model has been concluded.

The second phase requires that the developed model be validated through a series of measurements on point to point radio links. The Bahrain – Dhahran point to point link is targeted first. The transmitter station is located at the GCC Telecom Bureau in Bahrain while the receiving station is setup at KFUPM, Dhahran.

This measurement campaign on the Bahrain-Dhahran link envisages measurement of the field strength for frequencies in the range of 30 MHz to 3 GHz. It has been observed that International Telecommunication Union (ITU) has not issued any recommendation that provides a mechanism to include weather conditions in computation of the field strength or propagation loss for the frequency range mentioned above. In particular, determination of the variation of signal strength in the presence or the absence of ducting is important in predicting the field strength. Through this study, a mechanism has been suggested in order to compute/predict field strength/propagation loss taking weather into account and using the concept of refractivity and its gradient as a derivative of the weather [1, 2].

A number of simulations were performed and it has been observed that the value of computed/predicted field strength obtained is affected in the presence of weather. The reception of field either deteriorates or enhances depending upon the prevailing weather conditions. The weather effect on propagation is considered by including the weather in terms of refractivity gradient as explained in ITU recommendations (ITU R 370 [3,4], ITU R 1546 [5] and ITU R 452-10 [6]) in addition to other propagation models. It is observed that none of these recommendations provides mechanism to predict or compute field strength or transmission loss for the frequency range between 30 MHz to 3 GHz. The proposed propagation model fills this gap and provides a mechanism to compute/predict field strength and transmission loss for the frequency range between 30 and 3000 MHz.

A Point-to-Point link is established with the transmitter located at GCCTB office and the receiver at RI of KFUPM. Initially, the transmitter used two Log- periodic directional antennas (LPDA) to cover the frequency range 80 to 3000 MHz. The receiver used two omni directional antennas. However, during testing of the link it was discovered that the link is not functional at the selected frequencies in 30-3000 MHz band. Consequently, the antennas at both the transmitter and the receiver were replaced with four LPDA and two dish antennae. Thus, the transmitter and the receiver have identical antennae on both ends. At any time only one link consisting of one transmitter and the corresponding receiving antennae operating at a selected frequency is active. This functionality is provided on both sides through the manual switching device. So the selection of antenna is performed manually on both sides. The six antennae provide the facility to cover the specified frequency range and two different types of polarizations.

The received field strength is received by a specific antenna connected to a spectrum analyzer, which converts the signal strength data into a digital format. The spectrum analyzer is interfaced via a General Purpose Interface Board (GPIB) card to a personal computer where the received data is recorded. In order to be able to control setting up of frequency, polarization, and sweep time, reference levels, and other required parameters from the personal computer to the receiver, a graphical user interface was developed. This interface provides full control to the receiver for the selection of frequencies, polarization, sweep time, other required parameters, and text file handling and storage facilities. The received field strength is stored in text files.

The objective of this study is to conduct measurement of field strength, transmission loss, and received power at the receiver installed at KFUPM. It required setting up a point-to-point link between GCCTB office in Bahrain and KFUPM, Dhahran. The transmission loss, field strength, and received power is measured and recorded through a data acquisition system connected with the receiver. This system automatically records data for use in tuning and validating the developed *a Propagation Model* in the study conducted earlier. This tuning process of the said propagation model is to be performed using the ICS Telecom Package of ATDI, France.

II. Point to Point Link

The entire link has been divided into two parts as transmitter and receiver having six identical antennae on both the sides. This schematic diagram of the transmitter side is shown in Figure 1 while the reception side is shown in Figure 2.

A mechanical switching device along with Low Noise Amplifier is attached to the spectrum analyzer to receive the signal. The frequency and antenna selection is made through manual intervention. The set of low range LPDAs are fed directly to the spectrum analyzer while medium range LPDAs and dishes are fed through LNA. The spectrum analyzer is connected to a controller (a personal computer) through a General Purpose Interface Board (GPIB) card interface. The commands are issued to the spectrum analyzer to record the data in a text file on the PC through a Graphical User Interface (GUI) on an intermittent basis. The signal strength level is collected every 15 s interval. This interval can be adjusted as desired. The other parameters for the spectrum analyzer may also be issued through this interface.

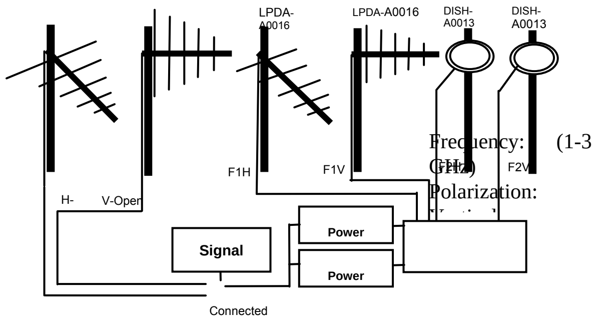


Figure 1.Schematic diagram of Transmission side of the Link.

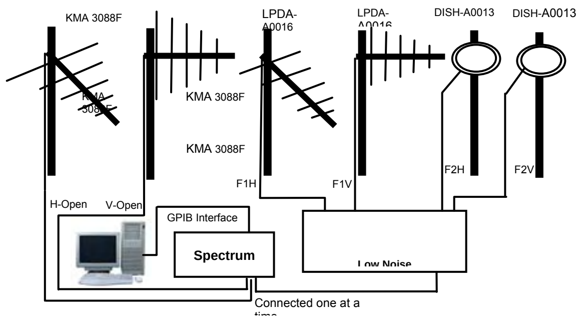


Figure 2. Schematic diagram of Reception side of the Link.

S. No.	Type	Freq. Range (MHz)	Polarization	Remarks
1.	LPDA	30-80	Vertical	KMA 3088F Log Periodic Antenna mounted vertical
2.	LPDA	30-80	Horizontal	KMA 3088F Log Periodic Antenna mounted horizontal
3.	LPDA	80-2000	Vertical	TRM LPDA-A0016 (mounted vertical)
4.	LPDA	80-2000	Horizontal	TRM LPDA-A0016 (mounted horizontal)
5.	Dish	1000-3000	Vertical	Dish-A0013 (mounted vertical)
6.	Dish	1000-3000	Horizontal	Dish-A0013 (mounted horizontal)

The testing of reception and transmission of field strength was conducted prior to start of the study. Data collection was made for different hours of the days and on different days for a set of test frequencies. Each of the transmitter and the respective receiver was

Top

activated to measure the field strength. The established link is to cover the transmission/reception of signal for the range of frequencies from 30 MHz to 3 GHz. The actual antennae assembly and data acquisition system on the receiving side at KFUPM are shown in Figures 3 and 4, respectively.

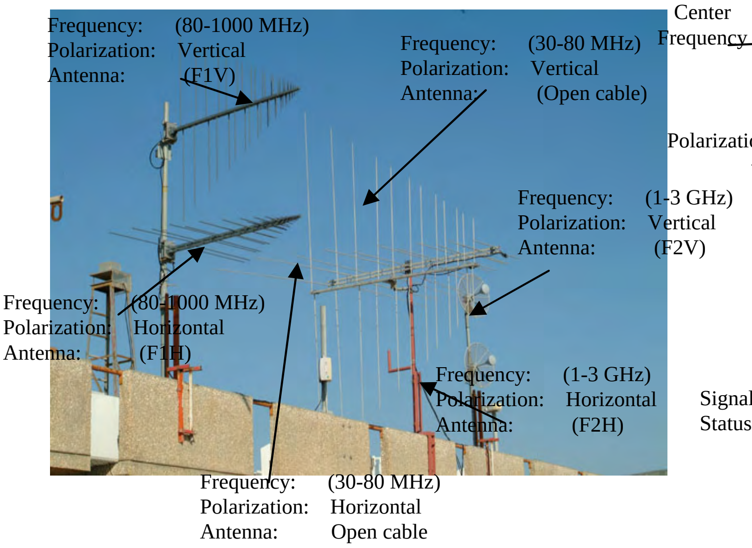


Figure 3 Receiver antennae

Figure 4 Data Acquisition System

A number of tests were conducted prior to the launch of the study for observing the reception of signal at the receiver. The measured field strength is recorded for different days and times on 24 hours basis.

III. Data Acquisition Interface

KFUPM has developed a graphic user interface (GUI) to record the data on a personal computer by issuing controls to the spectrum analyzer. The GUI is developed in visual basic.

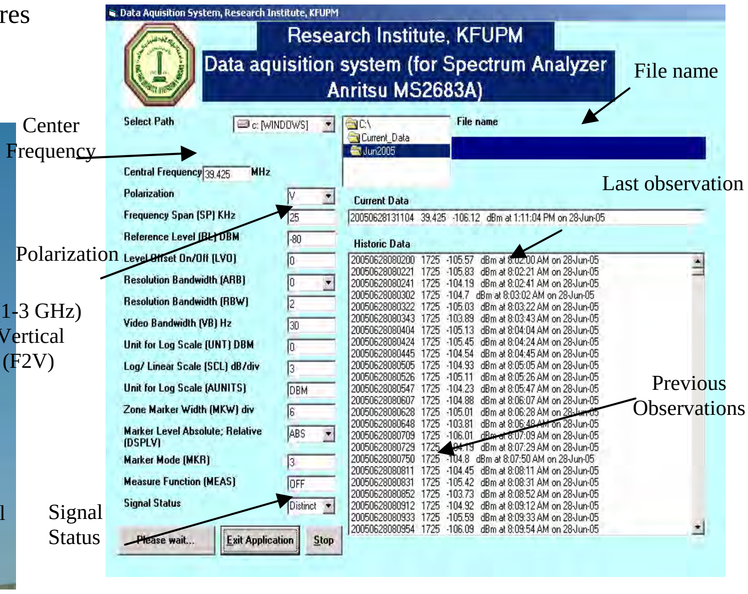


Figure 5. Graphical User Interface of Data Acquisition System.

The function of the interface is to capture the values of the received power at the spectrum analyzer connected to the antenna. The interface provides an option of issuing controls to the spectrum analyzer for its initialization and configuration. It also sets up the required center frequency, polarization; sweep parameters etc. for the spectrum analyzer. The data is recorded in text file, which is used for data analysis and processing. These text files are automatically generated by the interface having a time stamp. The interface have the feature of showing the last measured signal strength at a time in a single line window and other previous values in scrollable window apart from the issuance of controls. A snap shot of the interface is shown in Figure 5 and a snap shot of the received signal at the signal generator is shown in Figure 6.

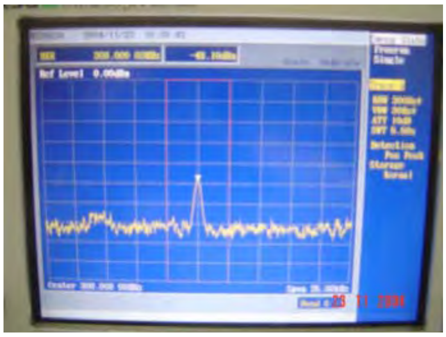


Figure 6 A Snapshot of the Received Signal

Top

IV. FIELD STRENGTH MEASUREMENTS

A number of frequencies in VHF, UHF and microwave range are allocated for the measurement. These frequencies are being used with vertical and horizontal polarization. Hence, in a total of 56 different combinations of transmitted signals (28 frequencies with horizontal or vertical polarization) were to be monitored during this measurement study.

The recording of field strength data was commenced from January 1, 2005 and is being conducted on 24 hour basis. The field strength data are collected every 15 sec and is recorded for at least an hour. The data files are in annotated with value of the frequency, time, and type of polarization used. For analytical purposes, another utility is written to group the data, as per requirement, on like hourly, weekly, monthly, or even yearly basis for a particular type of polarization and frequency. For an example a test conducted on August 15, 2005 having a transmitted power of 12 W is plotted for horizontal and vertical polarization for frequencies between 80-600 MHz and is shown in Figure 7.

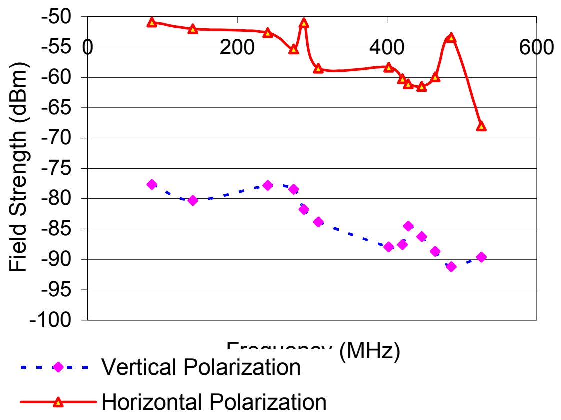
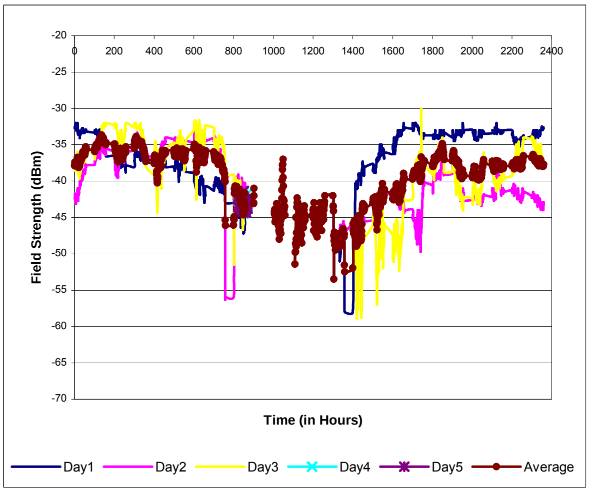


Figure 7. Field strength for frequencies between 80-600 MHz

A typical plot of recorded field strength for a frequency of 85.7 MHz using vertical polarization antenna is shown in Figure 8. The field strength for five different days, and its average is plotted on 00:00 Hours to 24:00 Hours time scale and is shown. It may be observed that the field strength is missing on some of the time because of the absence of the data.



V. CONCLUSIONS

The field strength measurement for low, medium and high range of frequencies has been recorded for a period of six months and this activity is going to be continued for another six months. During this period, it has been observed that the signal reception is strong in the low range of the frequencies (30-600 MHz) but starts fading away after 700 MHz and almost disappears after 1760 MHz. The losses are more in the higher range than that in the lower range. The transmitted power requirement is also studied. It has been observed that the minimum power required for the frequencies up to 400 MHz is about 10 W. At the same level of transmitted power, the signal fades away in case of frequencies more than 600 MHz. The tuning of the propagation model is in the process and needs to be concluded at the end of study.

VI. CONCLUSION

Although reading these instructions may have been an unpleasant experience, following them will improve the quality of your paper and the IEEE-GCC2006 Proceedings. Table I summarizes much of the detail provided and illustrates one of the rare instances where the double column format can be violated. If you have comments, suggestions, or are willing to volunteer your time to improve these instructions, please contact one of the IEEE-GCC2006 TPC Chairs.

ACKNOWLEDGEMENT

The work reported here was performed under the contract no. CCCR2202 and CCCR2209. The author would like to thank GCC Telecommunication Bureau, Bahrain for giving permission to publish the preliminary work. The author would like to acknowledge the support of the Research Institute of King Fahd University of Petroleum and Minerals, Dhahran, Saudi Arabia for providing support in conducting this study.

References

[1] B.R. Bean and E.J. Dutton, 'Radio-meteorological parameters and climatology', *Telecommunication Journal*, v. 43, pp. 427-435, 1976.

[2] International Telecommunication Union, *Hand Book on Radiometeorology*, Radio Communication Bureau, Geneva, 1996.

[3] T. Martin, *Implementation of the propagation model ITU-R P.370-7 in ICS-Telecom Software*, September 1999.

[4] VHF and UHF Propagation curves for the frequency range from 30 MHz to 1000 MHz Broadcasting Services, Recommendation ITU-R P.370-7, 1995.

[5] Recommendation ITU-R P.1546.

[6] Prediction procedure for the evaluation of microwave interference between stations on the surface of the Earth at frequencies above about 0.7 GHz, Recommendation ITU-R P.452-10, 2001

Top