Design of a generic, portable channel sounder with GPS capability

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***Abstract*—This work-in-progress paper briefly describes the design of a generic, low power, portable, real time processing channel sounder which can be used in the SHF (Super High Frequency), UHF (Ultra High Frequency), VHF (Very High Frequency), and HF (High Frequency) bands of communication.**

I. Introduction

Radiowave systems utilizing the earth-ionospheric waveguide channel is strongly dependant on ionospheric conditions. Signal propagation is determined by the state of the ionosphere [1]. Channel sounders are used to characterize these communication channels, specifically regarding ionospheric effects on signals as seen in Fig. 1. Data obtained from these sounders in combination with statistical channel models are used to develop generic channel simulators. These channel simulators can be used to compare different modulation and encoding techniques under different channel conditions without the need of in-field testing. Fig. 1 shows the influence of the ionosphere on radiowave systems.

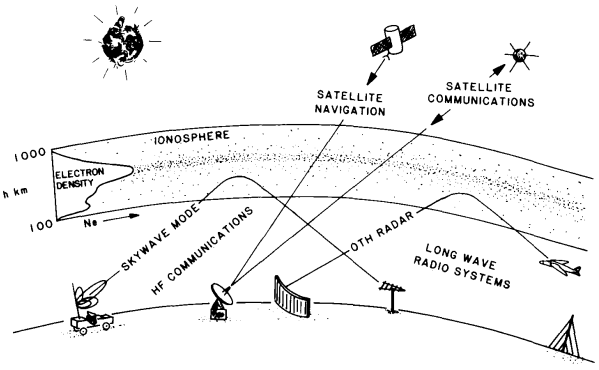

Fig. 1. Ionospheric effects on radiowave transmissions [1].

II. Problem statement

Current channel sounders in South Africa are very limited in their capability to form a adequate approximation of the ionosphere channel characteristics over a large area. Only a discrete number of fixed, large channel sounders currently exists. If the ionosphere characterization is needed on a trajectory path not close to actual sounder results, extrapolations are made and only approximations can be given. A complete characterization of the ionosphere over the whole of South Africa or a simple and fast method to characterize the channel in a certain direction, will be of great use to ionospheric physicists, the military and telecommunication companies.

III. The Project

The proposed project is the design and prototyping of a generic, portable, low power, real time processing channel sounder for use in the HF, VHF, UHF and SHF bands with integrated GPS capabilities.

A. Portability

Portability of the device is very important as there is a need to easily characterize certain communication channels and if possible, obtain a complete 3D model of the ionosphere within South Africa. Current deployed channel sounders are too large to relocate in order to obtain a more precise model of the ionosphere as communication channel. As mentioned, data for uncharacterized channels have to be extrapolated to be able to obtain a mere approximation of the ionosphere characteristics.

It is generally assumed that the characterization of a certain channel is reversible - when a channel is characterized in one direction the response of the channel is identical in the reverse direction. This however may not always be true, especially with the complex composition of the ionosphere and the various factors such as incident angle playing a role. A portable sender/receiver pair will make it more plausible to be able to characterize the channel in both directions. Fig. 2 shows the need for extrapolation and bidirectional channel characterization. X1-X2 and Y2-Y1 pairs represent fixed channel sounder pairs.

B. GPS capabilities

GPS will be used to synchronize the emitter and receiver for the channel sounder. Since GPS time is specified as being accurately synchronized up to 1 ns, a resolution of up to 6 m

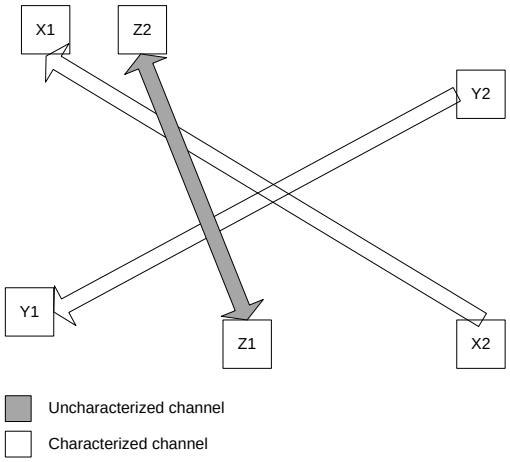

Fig. 2. Uncharacterized channel extrapolation and bidirectional characterization.

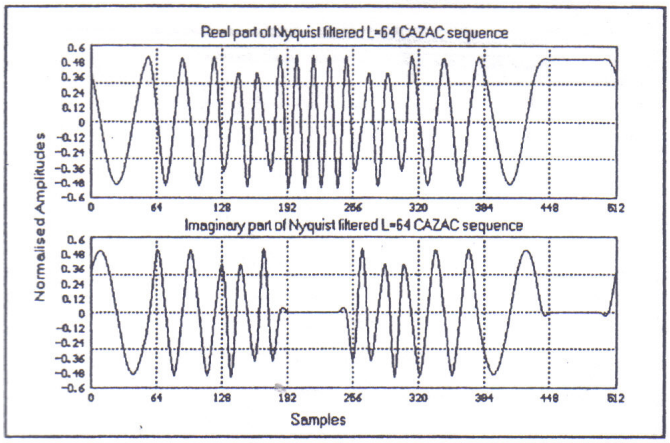

Fig. 3. Real and imaginary components of a Nyquist filtered L=64 PS-MP CAZAC sequence (8 times oversampled) [2].

in position can be obtained. This offers a significant increase in performance over previous methods. Signals were sent to the emitter-receiver pair from a control station, taking signal delays into account, causing the emitter-receiver pair to turn on with an accuracy of only 1 ms, resulting in an error of approximately 6 km in signal propogation. Integrated GPS will also be used for comparing data to ionospheric models obtained using GPS satellites. This data will verify models obtained by using GPS as channel characterizers.

C. Chirping Sequences

The proposed initial sequences to be used in the sounder is a certain class of polyphase sequences - Perfect Squares Minimum Phase Constant Amplitude Zero Autocorrelation (PS-MP CAZAC) sequences [2]. These codes have Constant Amplitude Fourier transforms and have ideal periodic Zero Autocorrelation (ZAC) properties. Constant envelope signals enable RF amplifiers to be operated in the saturation region, achieving a significant increase in transmission range. These sequences constitute the optimum sequences for maximum likelihood channel estimation.

Sequences of length $L = N^2$ will be considered, as originally proposed by Frank and Zadoff [3]. These PS-MP CAZAC sequences are of the form:

$$c(n) = e^{j\alpha_0 l(n)} \; ; \qquad n = 0, 1, 2.....L-1$$

where $\alpha_0 = \frac{2\pi p}{N}$ constitutes the basic phase angle in radians, N is the number of distinct phases of the (polyphase) code and p is an integer smaller than and relatively prime with respect to N [2]. Fig. 3 shows the real and imaginary components of a $L = 64$ CAZAC sequence.

D. Real time processing

In order to effortlessly construct an accurate ionospheric channel model in near real-time, the sounder will be implemented on a low power, parallel processing FPGA. The parallel processing power of the FPGA will be harnassed to be able to process the data from the sounding process in real time. This data will typically be transferred to a portable PC or laptop and the data will be displayed in real time on the screen. T

IV. Conclusion

There exists a need for an effective, portable and generic channel sounder, especially in South Africa. This project proposed the design of such a channel sounder which can be used extensively in all areas of HF communication.

References

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[2] L.P. Linde and U.H. Röhrs, "On a Class of Polyphase CAZAC Sequences and their Application in HF Channel Sounding", *The Transactions of the SA Institute of Electrical Engineers*, pp. 110-123, June 1993. Proceedings of the IEEE, vol. 78, no. 3, March 1990.

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