Determination of GSM Received Signal Level from Atmospheric parameters using Kalman Filter Algorithm

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Abstract

Received signal level (RSL) is affected by the dynamics of the atmosphere through which it propagates. The atmospheric condition of an environment is important in the planning of a network. However, accurate received signal level (RSL) values are useful for telecommunication network planning. The strength of the received signal level depends on the distance between the transmitting site and the point of signal reception. Hence, this paper aims to develop a Kalman filter model to predict GSM received signal level from atmospheric parameters. Atmospheric parameters such as temperature, relative humidity and dew point were used as inputs in the development of the model. The model has a two stage approach which are the prediction stage(time update) and the measurement stage (correction stage). The prediction stage involves the projection of the estimates and the error covariance ahead. The measurement stage involves computing the Kalman gain, updating the estimates with measurement and the error covariance. The developed model showed an acceptable accuracy level from the comparison with actual measured values.The developed model showed improved values for received signal level.

Keywords: Dew point, Kalman filter, Received signal level, Relative humidity,Temperature

Introduction

The importance of mobile communication services to the economy of any nation cannot be overemphasized. The subscriber base of mobile communication services in Nigeria is on the increase . Thus, the yearning need for the adequate planning of mobile communication networks. The world is fast becoming a global village and a necessary tool for this process is communication, of which telecommunication is a key player. The level of development in the telecommunications industry around the globe is pervasive as one innovation replaces another within a short range of time. A major breakthrough is the wireless telephone system, which comes in either fixed wireless lines or the global system for mobile communication (GSM) (Wojuade,2005).The last few years have witnessed a tremendous growth in the wireless industries, both in terms of mobile technology and its subscribers. There has been a shift from the fixed to mobile cellular telephony. By the end of 2011, there were over five times more mobile cellular subscriptions than fixed telephone lines (Azibikwe and Obiefuna, 2014). Telecommunication related revenues have increased globally, with mobile and broadband services being the leading contributors, the number of mobile subscribers exceeding those on fixed lines in many countries (Ofcom , 2007). Nigeria made efforts to increase its broadband penetration from 8% to 30% in 2018. This attempt is still far behind International Telecommunications Union (ITU) target of 40% in 2015 for developing countries (Olabisi, 2015).

Empirical models are useful in the planning of mobile communication networks. Due to the differences in environmental structures, local terrain profiles and weather conditions, the signal strength and path loss prediction model for a given environment, with reference to existing empirical models, often differ from the optimal model. Accurate signal strength values are necessary for network planning (Eichie *et al.*, 2016).

In the Troposphere, the various propagation mechanisms include: reflection, refraction, scattering, diffraction, ducting. Changes in temperature, pressure and humidity in the troposphere, as well as clouds and rain influence the way in which radio waves propagates from one point to another (Bean and Dutton, 1968).

Under abnormal conditions such as ducting, the signal strength can also be enhanced and this enables the signals to reach unintended locations where they may constitute interference to other co-channel networks.

Temperature and relative humidity have been found to have some correlation with GSM Rx level (Afrand *et al*, 2016; Philippopoulos *et al.*, 2012; Esfe, 2015).

Relative humidity (RH) defines the amount of water vapour in the atmosphere relative to the maximum amount of water vapour the air can take at the same atmospheric temperature and pressure. Relative humidity of the saturated atmosphere is 100% and as atmospheric water vapour increases towards saturation point, atmospheric temperature decreases. In other words, relative humidity is inversely proportional to atmospheric temperature. Dew point is the temperature to which the atmosphere must be cooled to enable water vapour condense into liquid water or ice (RH=100%). Relative humidity and dew point are both reflections of the amount of water vapour in the atmosphere.

Kalman filter estimates the state of a dynamic system, even if the precise form of the system is unknown. The filter is very powerful in the sense that it supports estimations of past, present, and even future states. Kalman filter algorithm involves two main steps: the prediction step and the correction step (Kleinbauer, 2004).

The prediction step produces estimates of the current state variable, along with their uncertainties. The result of the next measurement corrupted with certain amount of error which includes random noise is observed and these estimates are updated via a weighted average. The weighted average has more weight toward the applied estimates with higher certainty. Due to the recursive nature of the algorithm, it can be performed in real time using only the present input measurements and the previously calculated state and its uncertainty matrix. The Kalman filter could be used to develop a model to predict GSM