Real-Time Frequency Estimation of Complex GMSK Signal of Green Communications Devices

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***Abstract*—Parameter estimation of signals of universal software radio peripheral (USRP) devices is crucial to solve the problem of phase offsets of received signals in distributed beamforming. For systems that will utilize the closed loop feedback algorithm where the receiver needs to send the received signal strength (RSS) values periodically to the beamforming node so as to take advantage of energy conservation, the frequency and phase of these signals should be estimated before smoothening by nonlinear filters. This article presents the estimation of the frequency offsets of a Gaussian minimum shift keying (GMSK) signal from N210 USRP devices in real time by using the Radix-2 fast Fourier transform (FFT) algorithm in GNURadio. For these green communications devices, most of the needed hardware parts have been software defined, thereby reducing the supposed energy consumption. The frequency offsets from reference carrier frequencies of 900 MHz and 2.4 GHz are less than 3 kHz each before the estimation, but the average offsets are 45 Hz and 100 Hz after the estimation, respectively. The high offset value experienced with the 2.4 GHz carrier was due to consistent interference from devices on that same frequency.**

***Index Terms*—Cramer-Rao lower bound, Gaussian minimum shift keying, maximum likelihood estimation, universal software radio peripheral.**

1. Introduction

In collaborative beamforming (CB) where two or more devices send their message signals jointly for the purpose of achieving long distance coverage, higher signal to noise ratio (SNR), energy efficiency, and node redundancy, there is a need for the receiver node to send back information in package form for the CB nodes for the purpose of parameter estimation. These signal parameters which comprise of amplitude, frequency, and phase need to be estimated and further smoothen by the CB nodes for a coherent signal reception at the receiving node.

A digital modulation format is needed to transform the feedback message from the receiver to a pilot tone for the CB nodes. Gaussian minimum shift keying (GMSK) has been and is still being used in global system for mobile communications (GSM) because of the constant envelope and the capacity to reduce sideband power which leads to out-band interference reduction in adjacent frequency channels[1],[2]. GMSK is a type of minimum shift keying (MSK) with no phase discontinuity and it uses Gaussian low pass filter for shaping the waveform as against sinusoidal filter in MSK.

This article only considers the frequency parameter estimation of complex GMSK signals. Two Ettus N210 Universal Software Radio Peripherals (USRPs) are used in real time to achieve frequency estimation. These green communication devices have most of the needed hardware parts but now software defined, thereby reducing equipment physical size, making them more energy efficient, and allowing for less complex computation with the use of software defined algorithms[3],[4]. This article uses the concept of green communication to imply the hardware used, the modulation scheme, and the estimation algorithm[5]. Baseband processing is now software-defined while the modulation scheme has further enhanced reduction in sideband radiation. Also, the frequency estimation algorithm used is less complex and energy efficient as it uses $N\log_2 N$ order of operation[6],[7] compared with the N^2 order used in discrete Fourier transform (DFT). The estimation block is created by using out-of-tree (OOT) in GNU radio and later made available in GNU radio companion (GRC).

'Real-time' frequency estimation using fast Fourier transform (FFT) cannot be done without buffering some required number of samples as required by DFT. This estimation was carried out for 1024 samples at a time while buffering subsequent incoming samples in packets.

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