USAGE OF DIGITAL AUDIO RECORD FOR CONSTANT ENVELOPE MODULATIONS DECODING

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Abstract. Paper outlines a simple method of using MathWorks MatLab for PSK or FSK modulation decoding from digital record of signal in audio band (using beat frequency oscillator). Decoding process is demonstrated on a 3PSK modulation and possibilities of other modulation decoding by the method are described.

Introduction

Phase shift keying (PSK) and frequency shift keying (FSK) are typical representatives of constant envelope modulations. In decoding process, carrier recovery circuit and symbol timing recovery circuit are required [1].

Various types of receivers offers beat frequency oscillator (BFO) signal for demodulation of any inter-frequency (IF) signal into audio frequency (AF) signal. This signal can be easily recorded using PC audio device for further processing in any software.

Decoding of 3PSK

Pulse position phase shift keying (3PSK) is a minimum sideband (MSB) method designed to provide a minimum of Fourier sideband energy for a given number of filter stages, while allowing the use of multistage filters having some short cascaded rise time (group delay). It is the preferred method for Cellular Phone use [2].

In this work a radio frequency (RF) signal was down-converted by ICOM-R10 communications receiver into IF of 455 kHz and mixed with BFO signal to AF [3]. This was sampled and recorded in PC into wave sound file and processed in MatLab.

Decoding process consists of a correlation analysis (cross-correlation function estimation) followed by a threshold comparison decision.

The first step is to set a length of data element. This was found by auto-correlation analysis of isolated synchronization part in signal, but can be derived from bit-rate and AF signal frequency. The second step is to isolate or make comparing signal sequence. Then the correlation analysis between data part of signal (figure 1a) and the sample can be done. If *f(n)* is comparing signal sequence, *g(n)* is 3PSK signal and *N* is its length, then

$$R_{fg}(n) = \sum_{\tau=1}^{n} f(N+1-\tau)\cdot g(n+1-\tau)$$

R_{fg} is the correlation function of size *2N-1*, where $R_{fg}(N)$ position gives the correlation level of comparing sequence with 3PSK signal from its first position etc. Therefor redundant part of correlation function result is suppressed (figure 1b). The fourth step is to find out a threshold level for decision process that leads into binary data rise. The binary signal is multiplied with a set of windows according to the data element length (figure 1c). Finally data are displayed (figure 1d,e).

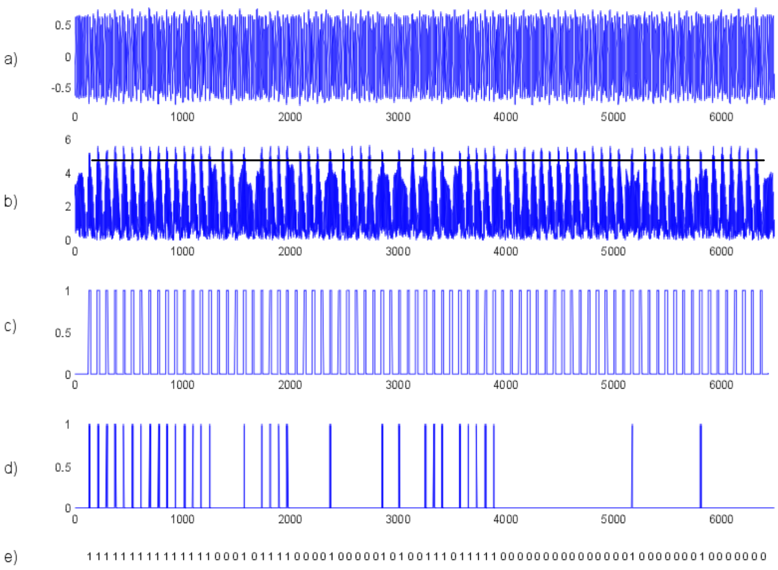

Fig. 1. *3PSK demodulation*

a) original 3PSK signal, b) correlation level and threshold,

c) set of windows, d) binary signal, e) decoded data

The advantage of the method is that no additive circuits are required. Only receiver and PC are necessary. On a contrary, the method has basic limitation in principle. A bit-rate is typically limited by AF bandwidth to 10kb/s when used 20 kHz signal frequency. The similarity to integral-based methods of PSK decoding is evident, but decoding process is in progress continuously, not per data elements.

Notes on other modulations application

This method was originally designed for use with 3PSK modulation and can be applied for differential PSK automatically. When a suitable synchronisation sequence in signal exists, also non-differential PSK modulations can be decoded. If placed in a cycle, FSK modulation can be decoded too.

Conclusions

The paper presents a simple method of low bit-rate PSK or FSK modulation decoding using any receiver with BFO signal and PC with MatLab software. The decoding process is based on a correlation analysis application.

The method is suitable for incidental use (radio-amateur or experimental links) and also for educational demonstration of correlation analysis application.

Acknowledgement

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References

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[3] ICOM R-10 Communications receiver service manual.