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Modulation Technique for Software Defined Radio Application

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Abstract: The role of radio in the communication systems have been extended from simple radio to mobile communications and beyond. Minimization or the replacement of hardware in communication technology through software has been resulted in the birth of a new technology, widely known as Software Defined Radio (SDR). This paper deals with the development of SDR to transfer information from one place to another place through channel. The incoming analog signal is modulated using phase shift keying (PSK) type modulation. Then add noise or interference to the channel. The transceiver is demodulated the modulated signal in order to retrieve the transmitted information. The results are confirmed that the programmed SDR can demodulate the various kinds of audio signal or any signal by software programming.

Key words: software define radio, phase shift keying, modulation/demodulation, digital signal processing

INTRODUCTION

Radio has been always fascinated human being since its discovery and invention. It provides information and entertainment to the people anywhere at low cost. The digital technologies and the advanced computer systems emphasized and started shifting from digital hardware to software implementation of systems. Digital signal processing (DSP) playing a very revolutionary role in the design and implementation of many practical systems with incorporation of the software. DSP can carry out variety of functions using same hardware. Today the DSP's are available and operated at very high speed at intermediate and radio frequencies. The introduction of software into the radio systems has brought the concept of software radio. Software radios have brought a revolution in the radio engineering. It is now possible to define various radio functions using suitable software on the same hardware. Such radios have been referred to as Software Defined Radio (SDR).

In USA, SDR research started as military strategy for construction of the continuous independent communication system. The mutual operating systems can be constructed by private or commercial communication network, when military communication network is destructed because of the nature disaster and war (Bergstrom *et al.,* 2002). Initially SDR was restricted to the military communication system. However, beginning in 1990, (pls insert full abbreviation of DARPA) DARPA leads the SPEAKeasy project. This SPEAKeasy is the first approach to commercial business for SDR technique and it was very successful. As a result, SDR becomes very useful new technique and can be expected to get the economical profits. However, since 1994, European Commission (EC) leads the development of the commercial system based on user's request for the service quality and definition of the communication infra-structure (Witkowsky *et al.,* 2002; SDR, Shiff, 2001; Pearson, 2001).

SDR technique can receive various kinds of modulation signal by software programming based on DSP due to its system flexibility system. Therefore, SDR can be considered as an important radio technique for 4G system and driving modes of the various radio network such as W-LAN (wireless local area network), W-PAN (wireless personal area network), cellular, digital multimedia broadcasting, etc (Nkjima *et al.,* 2001).

In software, SDR defines all aspects of functions both the transmit chain and the receive chain including modulation, de-modulation and frequency band selection (Nolan *et al.,* 2001; Prakasam and Madheswaran, 2007). During the early days, the deep space program is developed. However, currently PSK finds widespread use in both military and commercial communication systems. For telemetric applications, PSK is considered as an efficient form of data modulation, providing the lowest probability of error for a given received signal level during the measurement of over one symbol period. In addition, the terrestrial microwave radio links and satellite

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communication systems are also frequently employs the PSK as their modulation format.

In this paper, we have implemented the PSK modulation and demodulation technique to transfer audio signal using SDR. The programmed can be demodulated the modulation signal level without any peripheral hardware.

Methodology:

A communication system transfers information from one place to other over a channel. Information may include audio, video, data and many other signals. A simple radio system can be represented by block diagram as shown in Figure 1 where the SDR system is tested on audio speech. The software radio processing core uses a sequential processing block approach in which each layer can be added or removed as required. At the receiver end processing, the distortion of waveforms caused by the channel is to be undo and also be eliminated the effect of noise/interference on the received signal.

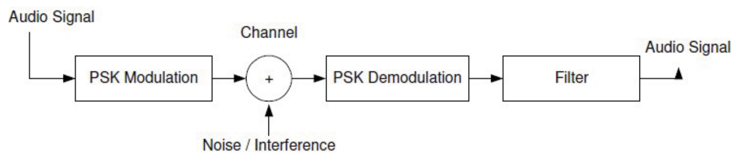


Fig. 1: Schematics diagram of radio system

PSK is a modulation technique in which the phase of the carrier wave is modified based on input signal to map data symbol to corresponding phase status. Binary phase shift keying (BPSK) signal is presented as equation (1) when the initial phase is zero.

$$S_{PSK}(t) = \begin{cases} S_1 = A\cos w_c t, & 0 \le t \le T_b \quad (for\, binary\, 1) \\ S_2 = A\cos w_c t, & 0 \le t \le T_b \quad (for\, binary\, 0) \end{cases} \tag{1}$$

The channel model used a modified Saleh-Valenzuela model for time-varying decay for fading. Radio system design problem states that an accurate channel model must includes a channel response in terms of a time-varying filter, a time-varying gain for fading and additive white Gaussian noise (AWGN) (Nolan *et al.,* 2001). With the exception of AWGN, the SDR channel model fits the constraint of the radio system. Additionally, this model is better than the Rician and a Rayleigh model because of its general form. We have added AWGN to the PSK demodulated signal separately in the simulation because the channel model does not include AWGN. AWGN is used to add noise to the transmitted signal to create the noise signal at the receiver. The adding noise is 20 dB below the average signal power (SNR = 20 dB). PSK demodulation is used to demodulate the signal and detect the transmitted signal.

The demodulation process can be divided into four major subsections such as carrier recovery, timing recovery, channel filter and data sampler as shown in Figure 2. Since the incoming waveform is suppressed carrier in nature, coherent detection is required. The methods by which a phase-coherent carrier is derived from the incoming PSK signal, termed as carrier recovery. Next, the raw data are obtained by coherent multiplication incoming PSK signal and carrier recovery signal. This raw data is used to derive clock-synchronization of the information. The raw data are then passed through the channel filter to shapes the pulse train so as to minimize inter-symbol interference distortion effects. However, the channel filter is sometimes placed at the IF (Intermediate Frequency) input of the demodulator with equivalent results. This shaped pulse train is then routed along with the derived clock of the timing recovery to the data sampler. The data sampler output is a demodulated data. The demodulated data will still exhibit an Mth-order of ±180° phase ambiguity which must be corrected.

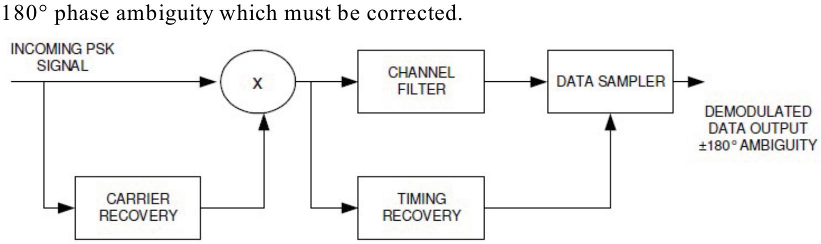


Fig. 2: Block diagram of PSK Demodulation

One of the major factors for degrading demodulator performance is inter-symbol interference (ISI) which is used to describe the pulse smearing between time slots in a band-limited channel. The idealized impulse response at the output of the data channel is the summation of equation (2) waveform as depicted in Figure 3.

$$\frac{\sin x}{x} \tag{2}$$

It is shown that the sampling occurs at multiples of Ts seconds in which the sin x/x wave shape guarantees the adjacent pulse "tails" pass through zero or zero ISI.

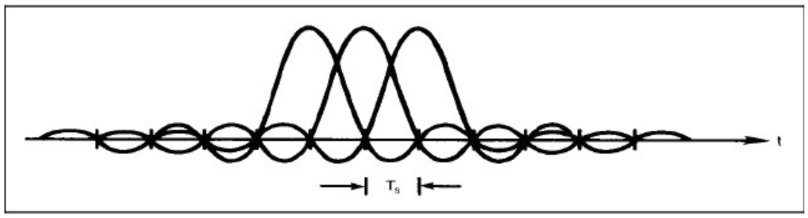


Fig. 3: Ideal impulse response.

Figure 4 shows the Fourier pair relationship of the optimal impulse response and shaping filter. The filter is an unrealizable ideal low-pass filter.

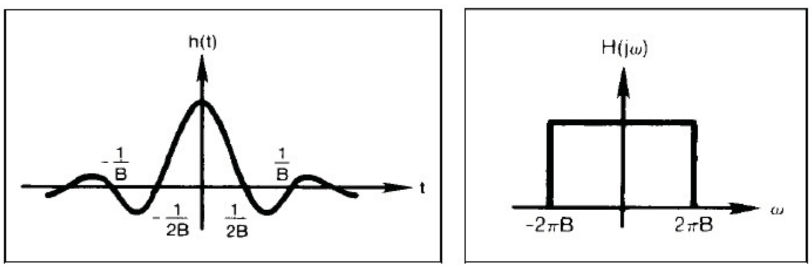


Fig. 4: Desired data channel a) impulse response b) required shaping filter.

PSK Modulation scheme detection is implemented using software radio system. Figure 1 shows a basic block diagram of a software radio receiver in which it is illustrated how the recognition section is integrated into the radio. The software radio processing core used a sequential processing block approach in which each layer can be added or removed as required resulting in flexible software radio architecture.

RESULTS

In order to implement the simulation, one has to understand the components inside the transmitter, receiver, and the channel. After studying the basic operating principles of the various components, one can choose the channel model and design algorithms for tasks such as PSK. The input signals are generated in MATLAB for PSK modulations. For the analog signals, audio signal is selected. This waveform is then modulated. Following that the AWGN is added to the waveform to simulate various noise conditions.

Figure 5 shows the various stages of SDR signal with respect to time in second. It is shown that the signal is transmitted 100% to the receiver. Figure 5(a) shows input signal. Figure 5(b) is the demodulated signal before filter and Figure 5(c) shows the output signal after using filter. Figure 6 shows frequency domain signals of corresponding time domain signals. Various audio signals are selected for the test in which it is shows the system performance.

Conclusion:

This paper described a PSK modulation scheme recognition technique for use in a software radio system. The technique is capable of determining the modulation scheme of a signal in the case when the digital modulation scheme class is not known a priori but PSK scheme.

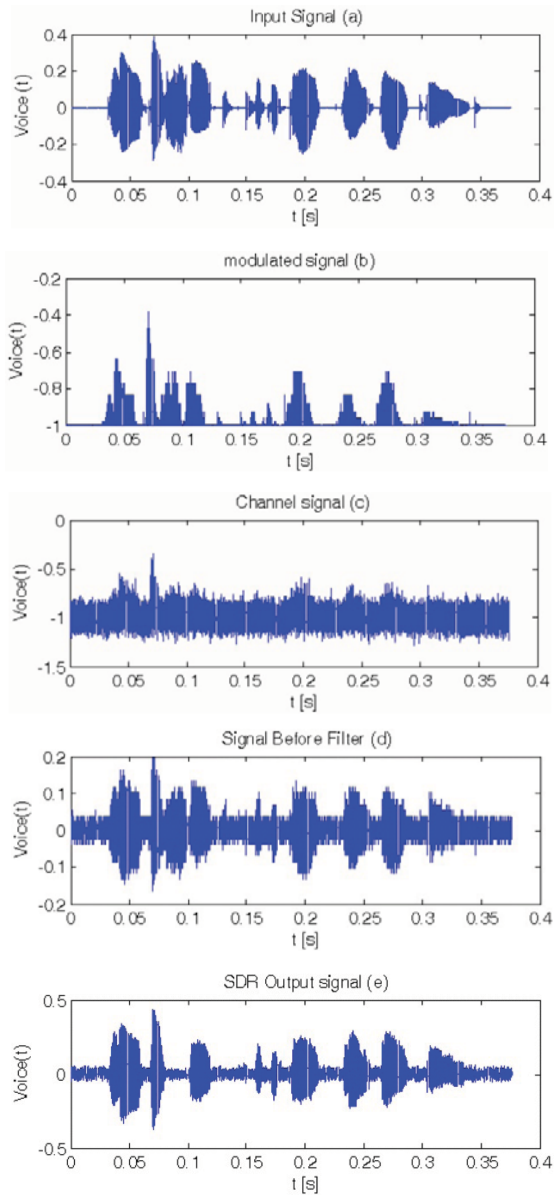
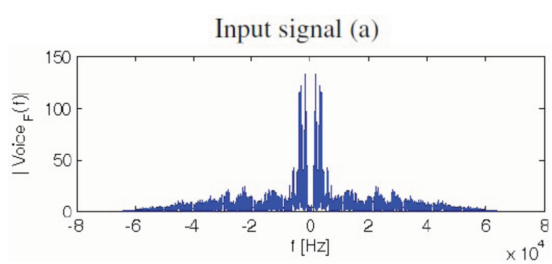


Fig. 5: Results of audio signal with respect to time in second



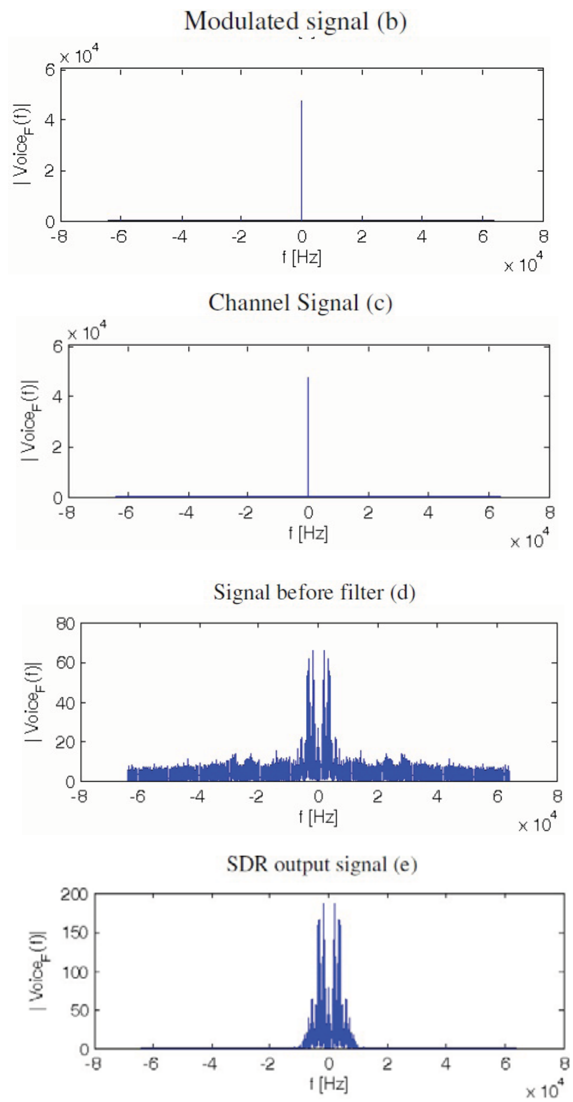


Fig. 6: Results of audio signal with respect to frequency in Hz

An SDR is developed using MATLAB language to identify the transmitted signal. This is signal can be either digital or analog modulated. The modulation type being considers PSK. Tests and simulations involving an intercepted signal, which is modulated using PSK shows that correct modulation scheme identification. As the technology for the SDR is growing, there will be increasing demand for better software that can add more capabilities to existing SDR systems. Further more, the ability to detect the received signal allows the flexibility for the SDR to adapt quickly to changing radio protocols. Further work will expand rang of identifiable digital modulation scheme.

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