

Performance of Primary User Detection Based on FFT for DTV Signals

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Abstract —In this paper, performance of primary user detection based on fast Fourier transform (FFT) is analyzed and simulated for advanced television systems committee (ATSC) digital television (DTV) signals. In order to detect the present and absence of the ATSC DTV signals, a pilot detection scheme based on FFT is employed. A wireless communication channel is modeled as Gaussian channel. For evaluating the spectrum sensing performance, detection probability is derived. We consider four kinds of sensing time, which are 5ms, 10ms, 20ms and 40ms. And we compare the system performances in accordance with the sensing time. From simulation results, it is confirmed that the spectrum sensing performance is improved as increase of the sensing time and the number of FFT points. The results of this paper can be applied to implement the spectrum sensing part of cognitive radio (CR) systems.

I. INTRODUCTION

A recent survey report for spectrum utilization which is published by Spectrum Policy Task Force (SPTF) within Federal Communications Commission (FCC) has indicated that most of the actual licensed spectrum bands are under-utilized in vast temporal and geographic dimensions [1]. In [2], it has been indicated that the maximum total spectrum occupancy is 13.1% from 30 MHz to 3 GHz in New York City and less than 35% below 3 GHz in Washington, D.C. Also, for as much as 90% of the time, large portions of the licensed bands remain unused cognitive radio (CR) [2, 3], which is the advanced scheme of software defined radio (SDR) [4], has been proposed in order to improve an efficiency of spectrum resource utilization. Besides, the IEEE 802.22 wireless regional area network (WRAN) has been suggested for achieving a high degree of spectrum utilization efficiency in radio spectrum currently allocated to the advanced television systems committee digital television (ATSC DTV) broadcast services and established related regulations and requirements [5-8].

In this paper, we propose and simulate the primary user detection method based on fast Fourier transform (FFT) for ATSC DTV signals. System performance is evaluated in term of a detection probability. A threshold value is determined by using the constant false alarm rate (CFAR) algorithm. A

wireless communication channel considered in this paper is a Gaussian channel.

The rest of this paper is organized as follows. In Section II, we briefly describe DTV signals. A DTV signal sensing algorithm based on pilot detection considered in this paper is illustrated in Section III. In Section IV, we analyze the system performance. Finally, concluding remarks are given in Section V.

II. ATSC DTV SIGNALS

The terrestrial broadcast mode, which is known as 8-vestigial side band (VSB), will support a payload data rate of 19.28 Mbps in a 6 MHz channel. A functional block diagram of a representative 8 VSB terrestrial broadcast transmitter is shown in Fig. 1.

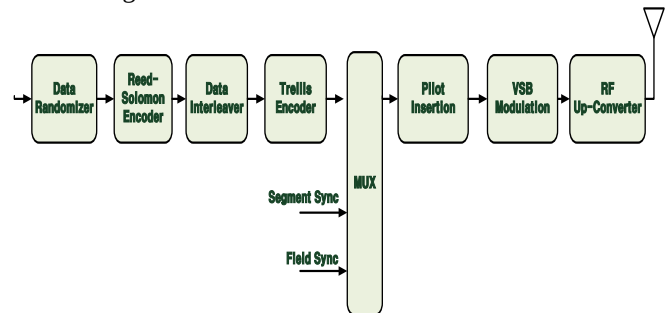


Fig. 1 VSB transmitter model.

A two-level (binary) 4-symbol data segment sync shall be inserted into the 8-level digital data stream at the beginning of each data segment. The data segment sync embedded in random data is illustrated in Fig. 2. A complete segment shall consist of 832 symbols: 4 symbols for data segment sync, and 828 data plus parity symbols. The data segment sync is binary (2-level). The same sync pattern occurs regularly at 77.3 ms intervals, and is the only signal repeating at this rate. Unlike the data, the four symbols for data segment sync are not Reed-Solomon (RS) or trellis encoded nor are they interleaved. The data segment sync pattern shall be a 1001 pattern [5].

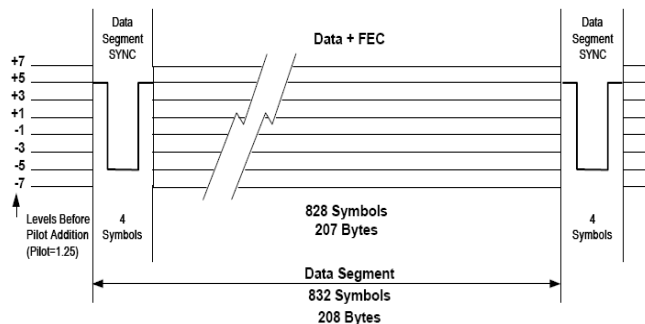


Fig. 2 VSB data segment.

III. SPECTRUM SENSING

The FFT-based pilot sensing techniques described in this section are non-blind (ATSC-specific) sensing techniques that meet the sensing sensitivity requirements of 802.22 and hence are classified as a fine sensing technique. The ATSC VSB signal has a pilot at the lower band-edge in a known location relative to the signal. Pilot sensing performs the signal measurements and determines the unoccupied channel by comparing the power estimated around pilot signals to the predefined threshold value. The basic steps of the sensing algorithm can be implemented with suitable modification for immediate frequency (IF) band and sampling rate.

ATSC DTV signal received pass through frequency shift process and filtering the low-pass filter of bandwidth 40 kHz. The filter bandwidth should be large enough to accommodate any unknown frequency offsets. Filtered ATSC DTV signal is down-sampled. Finally, we take FFT of down-sampled signal depending on the sensing period. 5ms sensing window will allow a 256 point FFT while a 20ms window will allow a 1024 point FFT. After FFT output value is squared, determine the maximum value [9]. This value is compared with the threshold value.

IV. SIMULATION RESULTS

We consider four kinds of sensing time which are 5ms, 10ms, 20ms, and 40ms. Also we analyze the system performance in accordance with the number of FFT points and related sensing time. And the wireless channel is modeled as Gaussian channel.

Fig. 3 and Fig. 4 shows the detection probability versus signal to noise ratio (SNR) performance for different numbers of FFT points when false alarm is set to be 5% and 10%, respectively. From the results, it is confirmed that the detection probability increases as the number of FFT points increases. In case of 256 FFT points, the detection probability is approximately 90% when the SNR is -17dB. But if the number of FFT points is more than 512, the detection probability exceeds 90% when the SNR is -20dB. Therefore, if the number of FFT points is set at more than or equal to 1024 points in this case, we can meet the criterion that the detection probability needs to be over 90% at the SNR of -20 dB.

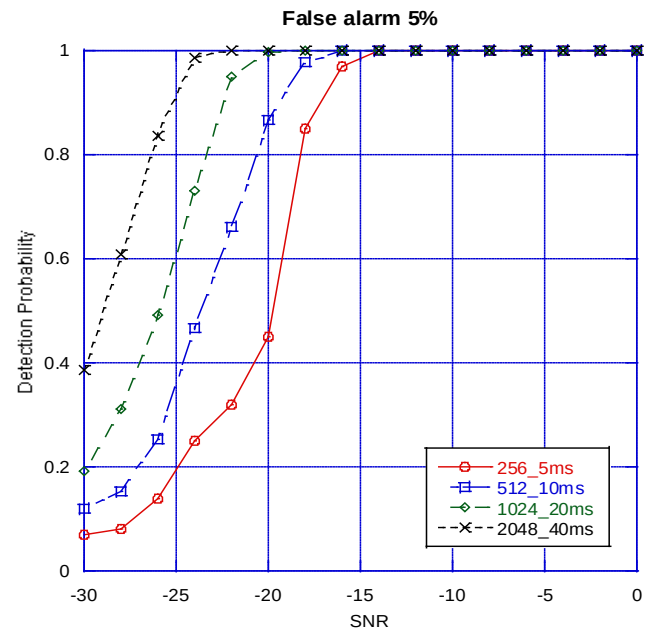


Fig. 3 FFT based on pilot sensing result (false alarm 5%)

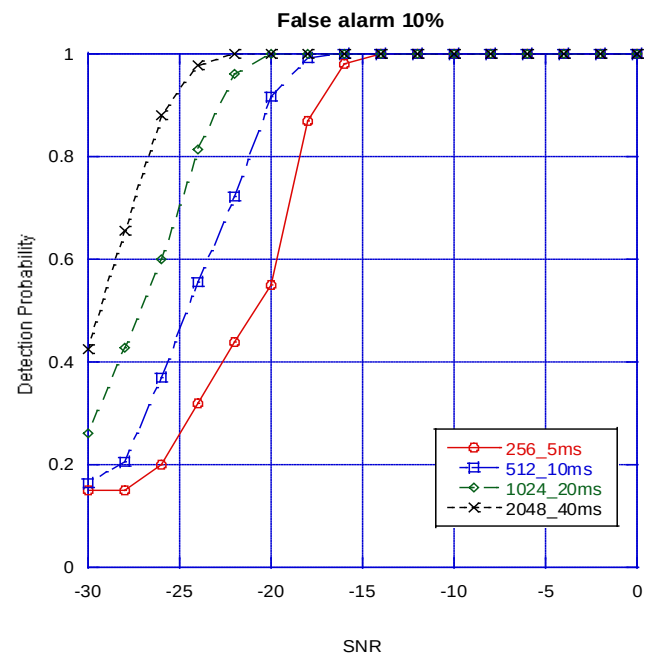


Fig. 4 FFT based on pilot sensing result (false alarm 10%)

V. CONCLUSIONS

In this paper, we proposed the primary user detection method based on pilot detection for ATSC DTV signals and evaluated the system performance in term of the detection probability. The threshold value was determined by using the CFAR algorithm. A wireless communication channel considered in this paper was modeled as the Gaussian channel. From simulation results, it was confirmed that spectrum sensing performance increased as the sensing time and the number of FFT points rose. It was also demonstrated that

spectrum sensing performance was improved according to increasing the sensing time. The results of this paper can be applied to implement CR systems.

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