Design of TV White Space Spectrum Sensing Receiver for Cognitive Radio

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Abstract

In this paper, we present a TV white space spectrum sensing receiver for cognitive radio. It is implemented with super-heterodyne architecture including tunable band-pass filter to improve selectivity and linearity. Low noise amplifier module is designed to operate in two gain modes for wide dynamic range. The algorithm is also developed to sweep the frequency, control the tunable filter, select the gain mode, and compute input spectrum, which are accomplished in PC using data acquisition board and analog output board. The measurement of the receiver shows the noise figure of 5.3 dB, input sensitivity of -106 dBm/2MHz, conversion gain of 103.6 dB and dynamic range of 89 dB across TV band (470 ~ 698 MHz).

Keywords: cognitive radio; receiver; spectrum sensing; TVWS.

1. Introduction

There is an increasing demand for new wireless services to use unallocated frequency band. However, the frequency resources are rapidly saturating and it is quite difficult to obtain new bands or to relocate the assigned band for efficient spectrum use. To solve these problems, researches on frequency-sharing techniques have been proposed using spectrum sensing and database of spectrum use, based on the fact that the many allocated spectrums are inefficiently used in the perspective of region and time [1].

Cognitive radio (CR) technologies utilize unused vacant channels for other wireless applications, which requires a spectrum sensing receiver to detect the unused channels [2]. In TV bands, there are many locally unused channels called TV white space (TVWS). The secondary user (SU) should be able to sense the primary user (PU) at very low power levels to protect PUs [3]. Therefore, the sensing receiver should have good sensitivity. There have been researches on the spectrum sensing in TV bands [4-5].

In this paper, we propose a spectrum sensing receiver operating in TV band (470 ~ 698 MHz). In section 2, the proposed architecture is explained. Algorithm and measurement results are presented in section 3.

2. Spectrum sensing architecture

Fig. 1 shows the block diagram of the proposed spectrum sensing receiver for TV band (470 ~ 698 MHz). The receiver consists of TV antenna, tunable filter, LNA module, up-converter, saw filter, frequency synthesizers and demodulator. RF signal is received by TV antenna. The tunable band-pass filter (BPF), which has 20 MHz bandwidth, scans TV band from 470 to 698 MHz in steps of 20 MHz. This narrowband filter reduces the spurious signals, which can improve the linearity performance of the receiver. The filtered signal is amplified by LNA module which operates in two modes, high-gain and low-gain modes. Single-pole double throw (SP2T) switches at input and output are used to select one of two modes depending on the input power. At low input power, the high gain mode is selected, which consists of three LNAs and BPFs. The low gain mode is comprised of a single LNA and BPF for high input power. In this way, the dynamic range can be greatly improved.

Next, the signal is up-converted to 955 MHz, while the local oscillation frequency (LO1) is swept from 1428 to 1650 MHz to cover TV band. Single TV channel is selected by the saw filter at IF. The demodulator down-converts the signal, demodulate and produce IQ baseband signals. It includes an auto gain control (AGC) function and variable gain amplifier (VGA) for wide dynamic range.

The baseband IQ and AGC output are read by PC through data acquisition board (DAQ board), and the input spectrum is constructed using sensing algorithm coded in Matlab. The algorithm also controls the tunable filter, SP2T switches, and LO1 through analog output board.

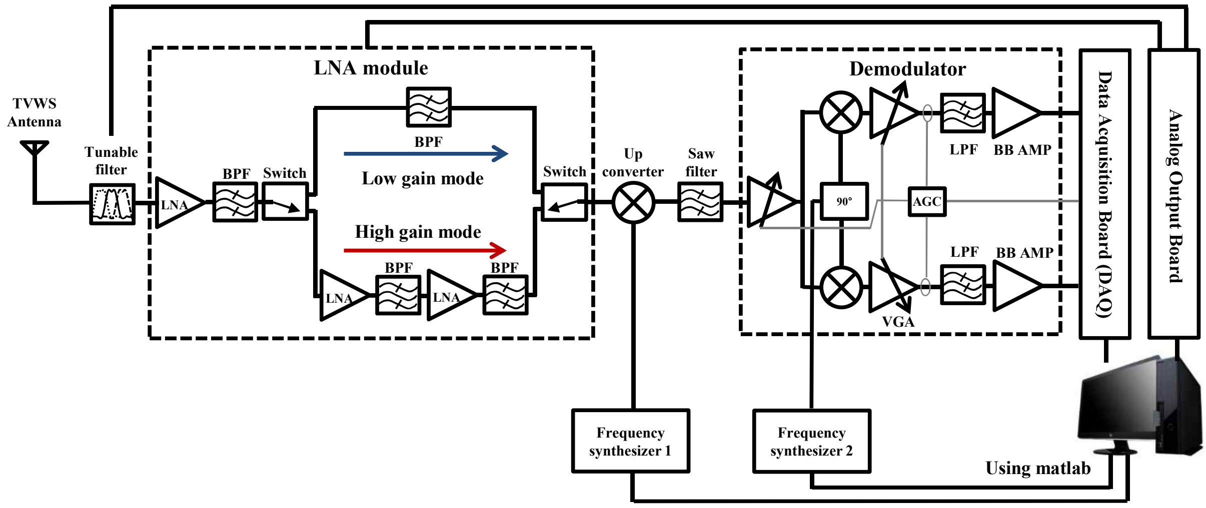

Fig. 1. The proposed spectrum sensing receiver.

3. Algorithm and measurement results

The input spectrum is calculated based on the AGC voltage (V_{AGC}). Fig. 2 shows the flow chart to compute the input power at a single channel. For this purpose, we took the measurement of the receiver performance such as conversion gain, dynamic range and noise figure, etc. Then, we developed the relationship between V_{AGC} and input power (P_{in}). The mode of LNA module is selected depending on the input power level.

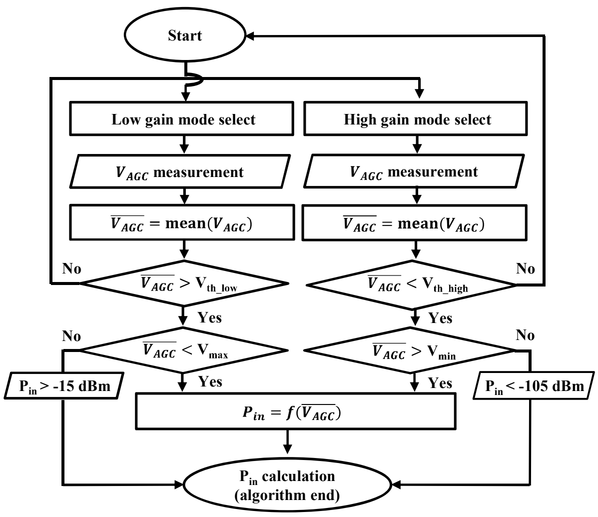

Fig. 2. Input power calculation algorithm.

Fig.3 show measured V_{AGC} of demodulator according to input power level using input power calculation algorithm. If input power level is -15 ~ -60 dBm, input power calculation algorithm selects low gain mode of LNA module. However, if input power level is under -61 dBm, input power calculation algorithm selects high gain mode of LNA module.

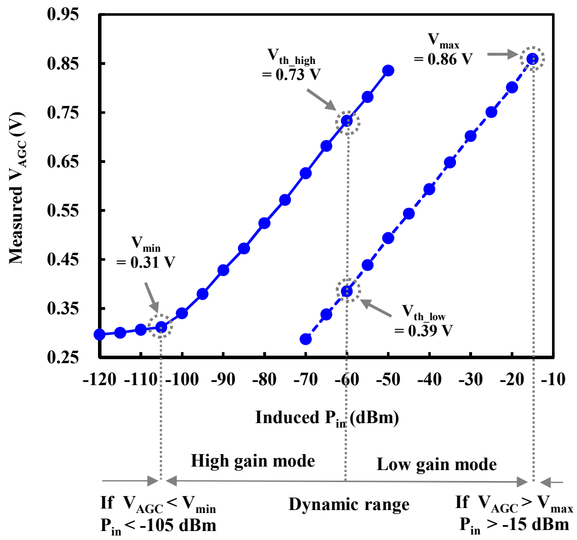

Fig. 3. Relation of measured V_{AGC} and induced P_{in}.

The measurement of the sensing receiver shows the typical noise figure of 5.3 dB, conversion gain of 103.6 dB, input sensitivity of -106 dBm (per 2 MHz) and dynamic range of 89 dB across 470 ~ 698 MHz. The whole scan time for entire band was 132 msec.

4. Conclusion

In this paper, we proposed the spectrum sensing receiver covering TV band (470 ~ 698 MHz) with excellent sensitivity, high conversion gain, and wide dynamic range.

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