# A Reconfigurable RF Front-End Receiver for Autonomous Spectrum Sensing Cognitive Radios

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***Abstract*—In this paper, a reconfigurable cognitive radio receiver for autonomous spectrum sensing is presented. A reconfigurable antenna, low-noise amplifier, reconfigurable bandpass filter, single-ended balanced mixer, voltage-controlled oscillator (VCO), and variable gain amplifier (VGA) build up the chain of the proposed receiver. This receiver targets the WLAN IEEE 802.11WLAN IEEE 802.11 g commercial wireless standard. The receiver performance is demonstrated with a 20-MHz down-converted signal at its output .**

***Index Terms*—Autonomous, Cognitive Radio, Reconfigurable, Software-Defined Engine, Spectrum Sensing.**

## I. Introduction

The broad frequency allocation, with the variety of the existing standards, calls for reconfigurable RF front-end spectrum sensing architectures [1]. Spectrum mobility, channel sensing, resource allocation, and spectrum sharing are important functional stimuli that constrain stringent issues on autonomous cognitive radios design [2]. In [3]-[6], the most common spectrum sensing techniques in the cognitive radio literature are given. These include energy detector, waveform-, cyclostationarity, radio identification, matched-filtering and sub-sampling based sensing techniques. The selection of a specific sensing method depends on several factors such as required accuracy, sensing duration, computational complexity, and network requirements. In order to cater for so many selection criteria, tradeoffs are considered. Therefore, a signal processing unit, with low-power consumption and a reconfigurable baseband signal processor, is needed.

Cognitive radio receivers are expected to process narrow-baseband signals received over a wide frequency spectrum. In other words, the RF components such as antennas, amplifiers, mixers and oscillators are expected to operate over a wide frequency range. This necessitates the move towards autonomously reconfigurable RF cognitive radio front-end architectures. Such architectures function in the presence of an efficient software-defined engine. This engine is not only expected to sense, process, learn and tune/control in order to guarantee an acceptable performance, but it is also required to account for RF impairments.

A wideband RF front-end architecture for software defined radio is proposed [7]. Starting from the original idea, which is based on digitizing the signal directly after the antenna of the software-defined radio, four RF front-end architectures are analyzed in terms of performance, power consumption, cost and size. These architectures, as illustrated in Fig.1, are: a) a bank of multiple narrow-band RF front-ends b) a wide-band architecture consisting of few medium bands, c) an ultra-wideband (UWB), and d) a reconfigurable RF front-end architectures.

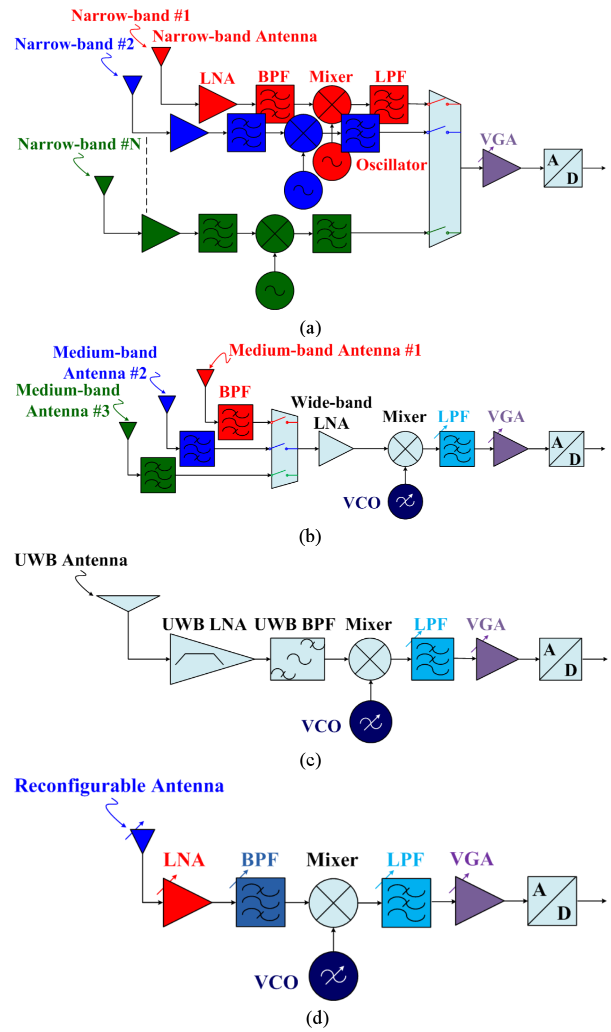


Fig. 1. RF front-end architecture: (a) multiple narrow-bands, (b) wide-band with few medium bands, (c) ultra-wideband, and (d) reconfigurable

The RF front-end given in Fig. 1(d) is chosen as the most convenient architecture to overcome the performance limitations due to inter-modulation (IM) products in an ultra-wideband environment. The multiple narrow-band architecture is not attractive because tunable preselect filters suffer from high insertion loss and of few standards support. As a result, the reconfigurable RF front-end architecture is adopted.

In this paper, a reconfigurable RF front-end sensing receiver for overlay cognitive radio applications is presented. The WLAN IEEE 802.11 g commercial wireless standard is adopted to validate the efficiency of the receiver's frequency tuning characteristic, while sensing the frequency spectrum. It's worth mentioning that the proposed receiver is capable of being driven by a software-defined engine to autonomously sense the frequency spectrum, process baseband signals, identify opportunities to increase the reliability of decision making, and reconfigure the chained RF functional blocks accordingly.

## II. The Proposed Reconfigurable RF Front-End Spectrum Sensing Receiver

A typical block diagram of the presented receiver is given in Fig. 2. The key specifications of the adopted WLAN IEEE 802.11 g commercial wireless standard are targeted in order to synthesize the proposed receiver and analyze its performance.

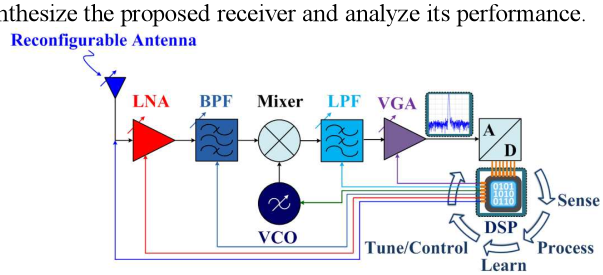


Fig. 2. Block diagram of the proposed reconfigurable receiver

A digital signal processing unit, which is composed of a software-defined engine, is expected to drive the above receiver. Accordingly, the sense, process, learn, and tune/control cycle is responsible of defining the functionality of the receiver-chain blocks.

In order to observe a down-converted signal in the decision making cycle, the received signal undergoes the following interrelated stages. The low-noise amplifier (LNA) is required to tune the receiver's noise figure to sense a minimum detectable signal (MDS) of -95 dBm according to the employed standard's key specification. After being amplified, the received signal's spurious frequencies are rejected through the reconfigurable bandpass filter (BPF), while simultaneously allowing the desired RF bandwidth to pass to the mixer. The mixer-low pass filter (LPF) unit, along with the voltage-controlled oscillator, down-convert the bandpass signal. The variable gain amplifier (VGA), which controls the gain level of the baseband signal, guides the observed down-converted signal to the decision making cycle. If the observed frequency band is being allocated, the software-defined engine starts a different channel sensing action. Otherwise, it occupies the current channel as long as the authorized user is not restarting transmission.

## III. Results and Discussion

An experimental setup to test the reception of the presented receiver is carried out. In this setup, two frequency sweepers are used. The first sweeper represents the transmitter side. It inputs an RF signal, whose $F_{RF}$ = {2.45, 2.46, 2.47} GHz and $P_{RF}$ = -10 dBm, into the receiver. The VCO block is replaced by another frequency sweeper, whose output has the following $F_{VCO}$ = {2.43, 2.44, 2.45} GHz and $P_{VCO}$ = 0 dBm values. Hence, an acceptable measured 20-MHz down-converted signal at the output of the reconfigurable receiver is attained as depicted in Fig. 3.

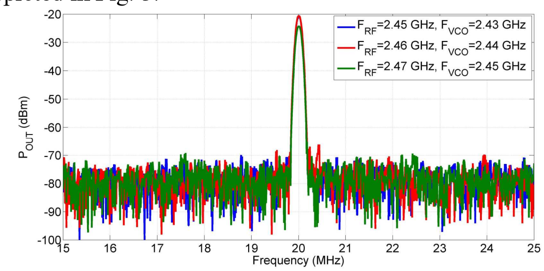


Fig. 3. Measured output power of the presented receiver

## IV. Conclusion

A reconfigurable cognitive radio receiver, which is capable of being driven by a software-defined engine to autonomously sense the frequency spectrum, is presented in this paper. For the targeted WLAN IEEE 802.11 g standard, a 20-MHz down-converted signal is received at the output of the receiver.

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