TVWS devices Spectrum Mask Test and Analysis

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Abstract—**Dynamic Spectrum Access (DSA) plays a vital role in opportunistic access to spectrum. A key component of DSA is preventing interference to the incumbent (primary) user from the secondary user. We present the results of an experiment to analyze the output signal and spectral mask of a low-cost TVWS device at specific power levels and specific channels in order to evaluate its potential level of interference to primary users.**

I. INTRODUCTION

There is an increase demand in spectrum use and spectrum has become a scarce resource even though in many areas spectrum is under-utilized [1]. To solve this issue of under-utilization, the Dynamic Spectrum Access (DSA) [2] concept was introduced. DSA enables users to determine available spectrum and detect the presence of incumbent users, when in operation [3]. DSA is a useful approach to use spectrum opportunistically for Internet access and allow secondary users to coexist with incumbent users. However, a key challenge in DSA networks is protecting primary users from Interference from secondary users at a given time or location. In order to avoid unwanted interference to primary users, spectrum databases need to accurately predict which channels can be used by secondary users and secondary user equipment needs to meet in-band protocol and power requirements and out-of-band emission requirements [4]. Interference with secondary users operating in the same channel or domain as incumbent users can occur but relies on carrier sense techniques to minimize the amount of interference. To protect Primary Users (TV receivers) from interference, we analyze the spectrum output of a low-cost TVWS device and produce its spectral mask to determine its characteristics.

Current Television White Spaces (TVWS) regulation in the USA and Europe allows channels 21 through 48 in the Ultra high frequency (UHF) band (SA channel) to be used but our device works from channel 29 to 39 corresponding to frequencies from 534 MHz to 622 MHz. Different test measures were taken in order to verify that the radio frequency (RF) output power is within the specified level by manufacturers [5].

II. OBJECTIVES

Our key objective is to understand the specific characteristics of the TVWS device. In order to measure these characteristics, we look at the following:

- Check if the measured power levels match the power levels set of on the white space device
- Check if the occupied bandwidth that falls within the set channel bandwidth
- Check for spurious emissions.

III. METHODOLOGY

To carry out these experiments we used the following devices and instruments:

- Spectrum Analyzer: We used a R&S FSH4 spectrum analyzer. Measuring the power emission and occupied bandwidth (OBW) for any given a certain frequency and time.
- RF Attenuator: In order to protect the spectrum analyzer from the high signal power we used 30 dB attenuator
- Doodle lab (TVWS card): This is a low-cost mini-PCI TVWS device that uses a transverter to down-convert WiFi to the UHF band.
- Routerboard: The TVWS card plugs into a Mikrotik 435G single board computer running OpenWRT
- Laptop: The laptop is connected to the router board to configure the power levels and channels.

Note the Doodle lab uses a down-conversion of 1872 MHZ and converts 2.4 GHz channels 1 to 14 (2412 to 2484 MHZ) to 540 to 612 MHz.

IV. MEASUREMENTS AND PROCEDURES

With the devices and tools stated in the previous section we were able to control the TVWS card and measure the output signal. The laptop set up the channels of interest and power levels using a web interface.

The router board and TVWS card together form the white space device (WSD). They can act either as a base station (BS), client terminal (CPE), or ad-hoc device if used in mesh mode. The experimental setup is shown in Fig. 1.

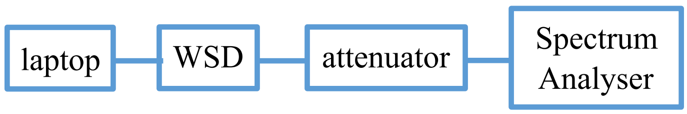

FIGURE 1: THE EXPERIMENTAL SETUP

The following procedure was used:

- Configure the network environment, by setting up the desirable channel 11(580MHz to 600MHz) and operation in the 5MHz channel bandwidth.
- We transmit signals at different power levels in 5 dBm steps from 0 dBm to 20 dBm
- We use 100 KHz resolution bandwidth (RBW).
- The trace was set to MAXHOLD.

We use the procedures listed above and produce the spectrum scans shown in Fig. 2,3. We use these scans to check if we can utilize the channel for coexistence. In Fig, 2, the power level was set to 20 dBm and it is clear that there are more out-of-band side emissions compared to Fig. 3 where the power level was set to 10 dBm. The power contained in the 10 MHz channel only decreased by 9.1 dBm when changing the power level from 20 dBm to 10 dBm due to more power leaking out of the channel when the output power was set to 20 dBm. Fig. 2 has less detail compared to Fig. 3 due to a larger resolution bandwidth being used (1 MHz compared with 100 kHz in Fig. 3). This shows the importance of setting a smaller RBW to see spurious emissions.

Figure 2: The measured power of the signal at channel 11 with power level set to 20 dBm.

Our focus is on spectrum emissions to test and analyze the in-band and out-of-band emissions. The in-band signal is produced by the white spaces devices in the channel we are communicating on [6]. The out-of-band emissions are the unexpected and unwanted RF signals that would be referred to as noise.

We also performed a spectrum analysis of all the channels the doodle device can use, Fig. 4 shows the result. The 5MHz steps between each channel can clearly be seen in this Figure.

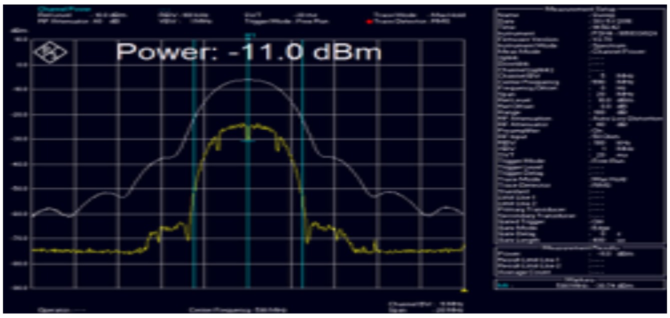

Figure 3: The measured power of the signal at channel 11 with power level set to 10 dBm.

V. CONCLUSION & NEXT STEPS

We performed a series of tests to evaluate the viability of secondary usage of TV broadcasting spectrum by a Doodle lab TVWS device. The tests included measuring the transmission power output level at different channels, evaluating the parameters of the transmitted spectrum mask and initial protection Ratio measurement. The tests helped to establish a methodology of measurements, as well as provided initial results assisting us to improve our design for a communication device using the card tested. The tests were done under a simplified conditions of a single device transmitting. In the next steps, we will extend the setup to address more realistic bidirectional communication.

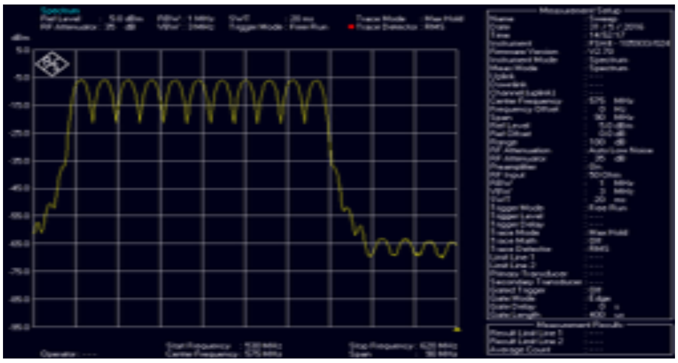

Figure 4: Spectrum scan for all channels from 1 to 11

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