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Sensing the TV band Using TV tuner

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Abstract

Spectrum sensing is a key to an enabling technology for white space access, because sensing is a method of measuring spectrum to detect primary transmitters for the express purpose of protecting the primary receivers (licensed users) and to avoid interference with secondary users (unlicensed users) by detecting and using only the available channels.

A novel low complexity system containing low cost TV tuner has been designed to sense the UHF TV band spectrum. The used tuner module was modified to scan automatically the UHF TV band spectrum. Microcontroller chip was programmed using micro Pascal software to control the TV tuner for scanning the TV band. This programed microcontroller chip controlled the TV tuner through internal Voltage Controlled Oscillator (VCO). The implemented system has been used to measure the utilization of the UHF TV band covering the frequency range from 470 to 860 MHz in Cairo (EGYPT). The designed system had a scanning time comparable to the commercial similar systems, and with lower cost.

The measurements have been taken at the ASUFE (Ain Shams University Faculty of Engineering) buildings, which roughly 4.5 km away from the TV transmitter station. The resulted data were analyzed to obtain the spectrum utilization.

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Aim of the work

This work aims to design and implement a system to sense the UHF TV band spectrum using TV tuner. Inspite to control the tuner, mikroPascal software will be used to program a microcontroller chip IC.

The system efficiency sensing in the UHF TV band spectrum will be studied. The output data obtained from the system will be analyzed and the results will be discussed.

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A Modified TV Tuner for Spectrum Sensing in TV UHF Bands

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ABSTRACT
A novel system containing low cost TV box has been designed to sense the UHF TV band spectrum. Microcontroller chip is programmed using micro Pascal software to control the TV tuner for scanning the TV band. The implemented system has been used to measure the utilization of the UHF TV band covering the frequency range from 470 to 860 MHz in Cairo (EGYPT). The sensing output data has been recorded and analyzed using suitable software. The obtained results demonstrate significant amount of spectrum available for deployment of cognitive radio systems and IEEE 802.22 WRAN standard in the UHF TV broadcasting band

General Terms
A new methodology for detecting UHF TV broadcasting band, TV tuner, UHF TV Spectrum usage.

Keywords
Cognitive Radio, Spectrum sensing, TV tuner, UHF TV band spectrum usage.

1. INTRODUCTION
Wireless communication systems were grown significantly. However this growth is faced by limits, because wireless communications is using the radio spectrum which is a finite resource. Cognitive Radio (CR) concept appeared trying to saturate this famine.CR is an intelligent adaptable wireless communication system that is aware of its surrounding environment and uses the methodology of understanding-by-building to learn from the environment and adapt its internal parameters, in order to detect the presence of the primary user signal, and detects the unused spectrum and shares it without harmful interference to other users. It determines which portion of the spectrum is available and detects the presence or absence of licensed users when a user operates in licensed band. In all countries, the government regulates the usage of the frequency spectrum by national regulatory institutions like the Federal Communications Commission (FCC) in the USA. In Egypt, the National Telecommunication Regulatory Authority (NTRA) is the governmental authority that administer the telecommunication sector. FCC coordinated allocating frequency bands and issuing exclusive licenses to systems within a geographical area while regulating other systems with respect to these bands.

1.1 SPACE SPECTRUM

1.1.1 TV Band Spectrum
In November 2008 the United States FCC issued a R&O on the unlicensed use of TV white space spectrum [1]. To operate in TV white space, there are requirements needed based on cognitive radio technology including location awareness and spectrum sensing. There are a number of other requirements intended to provide protection for the licensed services that operate in the TV bands. These requirements impose technical challenges for the design of devices operating in TV white space spectrum. FCC set rules managing the operation of the TV band devices (TVBDs).

There are two classes of TV band devices: fixed and personal/portable. The shorter term portable will be used for the personal/portable devices. These portable devices are divided into Mode I and Mode II devices.

Fixed devices are permitted to transmit up to 30 dBm (1 watt) with up to 6 dBi antenna gain, while portable devices are permitted to transmit up to 20 dBm (100 mw) with no antenna gain. Fixed devices are permitted to use a higher gain antenna as long as the transmit power is decreased dB-for-dB for any antenna gain above 6 dBi.

The Very High Frequency (VHF) channels (2-13) and the Ultra High Frequency (UHF) channels (14-51) are TV channels. However, there are restrictions on which channels are permissible for use by TVBDs. Channels (3-4) in the VHF channels and channels (36-38) in the UHF channels are not permitted for fixed devices. Fixed devices are forbidden to use channel (3-4) to prevent interference with external devices (e.g. DVD players) when they connect to a TV utility. Portable devices are not permitted at all in the VHF band. However they are permitted in UHF band except channels (14-20) and channel 37.Channel 37 is a protected channel, used for radio astronomy measurements. Finally, Portable devices are not permitted on channels (14-20) since, some of those channels are used for public safety applications [2].

1.2 SPECTRUM SENSING
Sensing the spectrum hole is an important requirement of cognitive radio network. In general, spectrum holes are categorized into two types, spatial spectrum holes and temporal spectrum holes. A spatial spectrum holes is unoccupied band by the primary user (PU) therefore the secondary users (SUs) can use it. A temporal spectrum hole is unoccupied band by the PU during the sensing time. Hence, the SUs can occupy this band in the current time slot [3, 4].

The spectrum holes are classified into three broadly defined types [5, 6]: Black spaces, which are occupied some of the time with high power RF signal interference. Gray spaces, which are partially occupied with low power signal. White spaces, which are free with RF interference except for white Gaussian noise.

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List of Abbreviations

CR	Cognitive Radio
CU	Cognitive User
PU	Primary User
SNR	Signal to Noise Ratio
PD	Probability of Detection
AWGN	Additive White Gaussian Noise
WRAN	Wireless Regional Area Networks
SSN	Spectrum Sensing Network
PWMS	Professional Wireless Microphone Systems
TVWS	TV White Space
NOI	Notice of Inquiry
SIR	Signal to Interference Ratio
ATSC	Advanced Television Systems Committee
Pd	Probability of Detection
Pm	Probability of Miss-Detection
Pf	Probability of False Alarm
DFS	Dynamic Frequency Selection
PSD	Power Spectral Density
PAL	Phase Alternating Line
NTSC	National Television System Committee
SECAM	Séquentiel Couleur a Mémoire
VSB-AM	Vestigial Sideband Amplitude Modulation
UHF	Ultra High Frequency
OTA	Over The Air
M2M	Machine to Machine
MAN	Metropolitan Area Network
WiMAX	Worldwide Interoperability for Microwave Access
WLAN	Wireless Local Area Network

HALO	High Altitude Long Operation
NICT	National Institute of Information and Communications Technology
RFID	Radio Identification
WPAN	Wireless Personal Area Network
SCL	Serial Clock
SDA	Serial Data
I2C	Inter-Integrated Circuit
FLO	Local Oscillator Frequency
F_r	Reference Frequency
CP	Charge pump
ADC	Analog to Digital Converter
RBW	Resolution Bandwidth
DTTV	Digital Terrestrial Television

Chapter (1)

Introduction and Literature Review

1.1 Introduction

Wireless communication systems have been widely and successfully deployed all over the world. Day by day, upper layer protocols demand high speed wireless access with very low delay requirements for applications in data, voice, video and other high bandwidth urge multimedia applications. However, the radio spectrum band available to serve the wide variety of all these emerging applications is strictly limited. The regulatory bodies licensed the radio spectrum, implementing strict limitations on operators and manufacturers protecting the radio resource and licensed users. This command and control nature of regulations limit the access of radio resource, which is a more important problem than the physical scarcity of spectrum. Further, it is discovered that, some frequency bands are largely underutilized most of the time or partially occupied, even in revenue rich urban areas. Cognitive radio was proposed a mechanism for efficient use such a free bands by exploiting its availability by cognitive users [1].

In order to complete these cognitive tasks in cognitive radio network, Cognitive User (CU) must perform additional tasks than normal wireless user. Detection of spectrum holes is called spectrum sensing [2].

Detecting the presence of spectrum holes needs sensing techniques. Three famous techniques are energy detection, matched filtering and cyclostationary feature detection. Out of these three techniques, energy detection is of particular interest due to its simplicity in implementation, its capability to detect any shape of waveforms and inherent privacy offered to the primary communication. Further, in this method, the primary user (PU) transmission is modeled as a signal with known power, and hence the energy detector is optimal [3].

In addition to applications in cognitive radio, the energy detector finds many applications in ultra wide-band technologies. Thus, the spectrum sensing by means of an energy detector requires detailed investigation. However, the reliability in spectrum sensing specified by the first cognitive radio standard IEEE 802.22 is yet not achieved by proposed techniques.

User cooperation is highly regarded as a means to improve the spectrum sensing in cognitive radio networks. In this method, spatially scattered individual CU decisions are combined and final decision is made. In another approach, cooperative relay gain being used for spectrum sensing.

Chapter one presents introduction about spectrum sensing and its importance and its ability to know where white spaces are in the frequency spectrum. In addition to display a summary of researches in the field of spectrum sensing from 2009 to 2015.

Chapter two illustrates the definition and evaluation of the policy spectrum changes set by the Federal Communications Commission as well as to test the prototype of the sensor spectrum in 2007. This chapter also provides cognitive radio definition, which mainly depends on the frequency spectrum sensing as well as the definition of spectrum sensing and display technologies used in the spectrum sensing and its advantages and disadvantages of each. In addition, TV signal types and methods of transmission bandwidth and space used to refer in Egypt has been reviewed. Also the importance of micro-controllers was highlighted briefly.

Chapter three shows a set of applications that use spectrum sensing, which opened the door to the exploitation of white spaces in the Spectrum, where the major companies in the field of communications are racing to use some of these applications to replace the hustle existing in spectrum, which leads to the occurrence of overlap between the signals such as used in the technique of WiFi at frequencies (2.4/5) GHz. Super WiFi technology is an application that works on unoccupied television frequencies and give the ability to cover larger areas and spaces.

Chapter four illustrates the design of the system used in this study and how to connect its parts, where the controller which has been programmed to control the TV tuner and make sure the system do the work of scanning the spectrum in the frequency range concerned by this study. Where the output signals was analog signals, and then these signals fed to