

Spectrum Sensing for Tv Band Using Ni-USRP and Lab View

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ABSTRACT: This Spectrum sensing is a most important component for the realization of Cognitive Radio (CR) systems in order to allow dynamic access to the radio frequency spectrum. The digital shift of TV transmission will make accessible some TV frequencies which are to be geographically idle called as TV White Spaces. We have performed spectrum measurements of TV band in Pune, India. Our result shows poor spectrum utilization in TV band and good potential for Cognitive radio.

The idea of this paper is to detect the presence of primary users to avoid interference with secondary users in cognitive radio networks. The performance of Cognitive Radio (CR) systems with Energy Detection with modulation is analyzed and CR is implemented using Universal Software Radio Peripheral National Instruments 2920. It is the widely used Software Defined Radio kit for learning digital wireless communication system.

KEYWORDS: Spectrum Sensing; USRP; Energy Detection.

I. INTRODUCTION

Cognitive radio (CR) has been launch as at alented technology to spectrum deployment in wireless communication. All the cognitive radio users are divided into the main (licensed) and derived users [3]. In a CRnetwork derived users scan the frequency spectrum (try to identify a spectrum holes in time or frequency domain)and adjust transmission parameters to genuine existing communication channel.The proposal of spectrum sensing is not new and several methods have been devised to hold out spectrum sensing at various levels in current times. The work done is discusses the time covariance method of spectrum sensing along with a thoroughrelative study of a few other techniques. Whereas, the research described in talks about anpioneering approach based on co-operative spectrum sensing between two nodes that are able of sharing data [9]. The three admired methods of spectrum sensing discussed in the above mentioned works are (1) Matched filter reception (2) Cyclostationary analysis and (3) Energy detection.Energy detector is also identified as radiometry or periodogram [7]. It is the most general way of spectrum sensing because of short computational and functioning complexities. The receivers do not need any information about the principal users. The arriving signal isdetected by comparing the output of the energy detector with a threshold. Matched filtering is painstaking as the suitablemethod for uncovering of main users if the transmitted signal is known a priori. It is also called as coherentdetector. The method requires fine knowledge aboutmain user signal such as modulation type, bandwidth,carrier frequency, etc. The test statistic is compared withthe threshold and in distinct form. Cyclostationary Sensing is also called Feature revealing. Cyclostationarybased sensing uses the sole pattern of the signal to identifyits existence. Cyclostationary description aregrounds bymodulated signals or in its figures like mean and Auto-correlation. Chief primary signals are modulatedby the sinusoidal carriers or have cyclic prefixes. Periodiccorrelation utility is used for identify signals in afrequency spectrum.

Cognitive access of TVWSs is the real opportunity for Wireless broadband connectivity to empowering rural India. It can improve rural people lives by affordable access to information, and knowledge we have presented results of the spectrum measurement campaign performed over the TV broadcast spectrum to understand the current utilization of TV band. To design the measurement set up, and methodology to conduct the measurement campaign. We have found the utilization of TV band is quite low. The result clearly shows the spectrum opportunities in India for cognitive radio operation in TV band. In this paper, the real time signal of TV band is received and energy is analysed to detect the presence of primary users using USRP NI 2920.

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II. LITERATURE SURVEY

First, Amanpreet S Saini, Zhen Hu, Robert Qiu in [2] has discussed about Spectrum Sensing of Cognitive Radio where it contract with spectrum sensing and spectrum renovation for cognitive radio. Spectrum analyzer is used to imitate cognitive radio to do spectrum sensing. The whole process of spectrum sensing including sensing setup, instrument control, sensing ability, sensing state and sensing outcome is presented in detail. The main advantage of equipment-based spectrum sensing is to perform swift and semi-continuous measurements. The time needed for each measurement is around 80-110ms. 3-D spectrums of CDMA, GSM signal, Wi-Fi signal and DTV signal are shown in this paper. Meanwhile, TV reconstruction method is working here to reconstruct the spectrum and find the margin of the frequency band which is occupied.

MaziarNekovee, in [5] discussed about review of Cognitive Radio Access to TV White Spaces where they surveyed the state-of-the-art in cognitive radio admission to TV White Spaces. They showed that a rigid Framework for secondary exploitation of TVWS spectrum is well underway both in the US and UK and central steps in this direction are also being taken within the EU and worldwide. Using result from currentderived studies of the TVWS accessibility in the UK and US we illustrated that cognitive access to these bands provides a very significant spectrum chance for a range of indoor and outdoor applications and services. Furthermore, quantitative techno-economical studies of the commercial feasibility and cost versus benefit associated with use cases of cognitive radio crucial in influencing the take-up of the technology by wireless network and service providers but are currently very limited.

KishorPatill, Knud Erik Skouby, Ramjee Prasad in [10] discussed about Cognitive Access to TVWS in India .The spectrum occupancy evaluation from measurement clearly shows the TV band is underutilized, and digital switchover of TV transmission not only produce digital dividend, but also create opportunity for cognitive operation in TVWS in India. Many scenarios are envisaged for opportunistic access based on cognitive radio in the TV whitespaces. In the context of rural areas wireless broadband access using TVWSs is the most suitable scenario for empowering the rural India. All the gram panchayats of India will get the broadband connectivity under National Optical Fiber Network (NOFN) project. They have proposed cost effective last mile connectivity to the small village population through wireless broadband network using TVWSs.

SaketSrivastava, Mohammad Hashmi and Supratim Das DibakarBarua in [13] discussed about real time spectrum sensing framework, and a novel machine learning technique to derive a general decision boundary to classify the busy channels from the free channels. In this paper, due to limitations of equipment, the spectrum sensing was restricted to only two bands. Since known transmitters exis in FM bands, supervised machine learning for spectrum classification was reliably performed for these bands. Other spectrum regions such as the GSM and Satellite Imaging bands posed unique problems such as real time frequency hopping (which would lead to a lot of discrepancy while declaring a spectrum as occupied or vacant) and lack of knowledge regarding exact times of transmission. Due to these reasons they could not be included in the dataset which aimed to create a reliable decision boundary for spectrum classification. Nevertheless in future datasets from the above mentioned bands and many other bands will be targeted to gather a larger training set spanning across multiple bands, and apply the same technique to evaluate its effectiveness. A similar approach can also be embraced for co-operative spectrum sensing, where multiple cognitiveradios sense the spectrum, and come to unified conclusion regarding the state of spectrum usage in real time.

III. TV BANDS IN INDIA

The terrestrial TV broadcasting in India operates in VHF and UHF bands. The frequency allocation of terrestrial broadcasting is in the line with the other parts of the world. The spectrum available for Terrestrial TV broadcasting along with TV channel distribution in India is given in table. The total spectrum presently available in India from VHF and UHF TV band is 413MHz. Doordarshan, the public TV broadcaster of India, has assigned only one channel (channel number 4) in the VHF band I for the terrestrial TV broadcast. Doordarshan has assigned all the 8 channels of the VHF III band for analogue TV transmission. There are 14 TV channels available in the UHF band-IV (470-582 MHz) with each having a channel bandwidth of 8 MHz.Doordarshan has assigned, and is operating about 330 transmitters in this band. Doordarshan's three digital TV transmitters at Kolkata, Chennai, and Mumbai are also operating on an experimental basis in this band.

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There are 28 channels available with a 8MHz bandwidth in UHF band-V from 582-806 MHz Doordarshan has not been assigned any channel in this sub band for analogue TV transmission. However, frequency band of 735-755 MHz and 775-795 MHz has been assigned to Doordarshan to operate short distance UHF links. Some of the Government agencies are operating point to point microwave lines in 561-806 MHz .In India, Doordarshan is the only national carrier for TV broadcasting, which covers almost the entire country. The Doordarshan runs very few channels such as DD1, DD metro, DD news, and regional channels. In contrast to this, Europe, and US runs many channels and uses all available TV channels. Traditionally, broadcast TV transmission takes place in VHF and UHF range in a 6-8 MHz band per channel. But, these band of frequencies which occupy different slots in the frequency range from 470-698 MHz, remain highly underutilized. Their usage pattern changes with geo-location, and in rural, and semi-urban areas, they are mostly unutilized owing to fewer broadcasters.

There is proposal of phase wise digitization of TV transmission in India by March 31, 2015. In this proposal, the four metros of Delhi, Mumbai, Kolkata, and Chennai will be the first to switch from analogue to digital, phase-II that includes 35 cities with population of more than one million will have to make the transition by March 31, 2013. All urban areas are expected to digitize by November 30, 2014 and the remaining areas by March 31, 2015. The key factors which are affecting switchover strategies include the size of the terrestrial platform, the availability of spectrum, digital terrestrial television (DTT) penetration, and coverage as well as compliance with international obligations.

Few TV channels cannot be used by TV stations in given geographical region after digital switch over since it can cause interference to adjacent or co channel TV stations. These vacant channels can be used by low power unlicensed devices without causing interference to adjacent or channel stations. The unused TV frequencies are known as TV white spaces (TVWS). The TV broadcast spectrum is licensed spectrum, which traditionally been used exclusively by licensed television broadcasters. However, regulatory rules don't allow the use of unlicensed devices in the TV bands, with the exception of remote control, medical telemetry devices and wireless microphones. The TVWS can be allowed for cognitive operation without causing harmful interference to the licensed users in TV band including wireless microphones. The introduction of CR in the telecommunication market may require new regulations, or changes to the way a spectrum is licensed, and the conditions under which it can be used. According to one study, the economic potential for the TVWSs was estimated at \$100 billion.

IV. ENERGY DETECTION

Energy detection is the most common way of spectrum sensing due to the lower computation required and no need of any knowledge about the possible signal. The detection could be done in time or frequency domain. Time domain implementation consists of averaging the square of the signal as shown in fig.1. Frequency domain requires an FFT whose size N improves frequency resolution helping narrow band signal detection and later averaging over the observation time as shown in fig 2. Frequency domain gives a second degree of freedom to improve the algorithm [1]. Finally in both cases, the result is compared with the threshold.

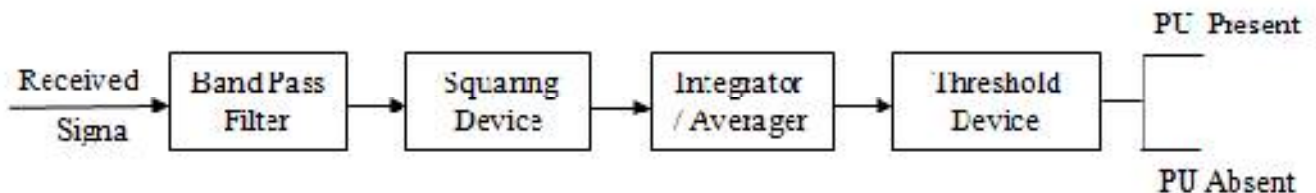


Figure 1: Time domain Energy Detector

The band pass filter selects the center frequency ' f_s ' and band width of interest ' W '. The Squaring Device which follows the filter measures the received energy. Then, the integrator determines the observation interval, ' T '. The output of the integrator is compared with the threshold λ_{th} which decides the presence or absence of the primary user.

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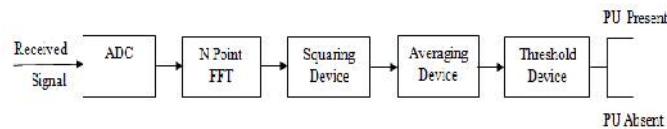


Figure 2: Frequency domain Energy Detector

In Energy detection method, the presence of primary user is detected by comparing the output of the energy detector (M) with a threshold (λ_{th}) which depends on the noise [1]. In discrete domain, the received signal can be represented as

$$r[n] = \begin{cases} w[n] & H_0 \\ (h*s)[n] + w[n] & H_1 \end{cases} \quad (1)$$

where $x(n)$ is the received signal, $w(n)$ is the AWGN, h is the amplitude gain of the channel, and $s(n)$ is the transmitted signal. When there is no transmission by the primary user, the value of $s(n)=0$. H_1 and H_0 are the two hypothesis formulated for the existence or non-existence of primary transmitter respectively. The Decision Metric for the Energy Detector can be written as

$$Y = \sum_{k=1}^M |x[n]|^2 \quad (2)$$

where N is the size of the observation vector. The decision whether the signal is present or not is dependent on the value of M .

V. LAB VIEW AND NI-USRP

Universal Software Radio Peripheral (USRP) is a range of software-defined radios designed and sold by Ettus Research and its parent company, National Instruments. Developed by a team led by Matt Ettus, the USRP product family is intended to be a comparatively inexpensive hardware platform for software radio, and is commonly used by research labs, universities, and hobbyists.

USRP is connected to the computer of the user with a link of high speed. USRP hardware is a transceiver used by computer of the user to perform data operations. Many USRP are capable to combine different operations of the computer operated by the user with different type of processor which can individually capable of performing operations. the graphical icons of USRP are easily available for coding. USRPs are commonly used with the GNU Radio software suite to create complex software-defined radio systems.

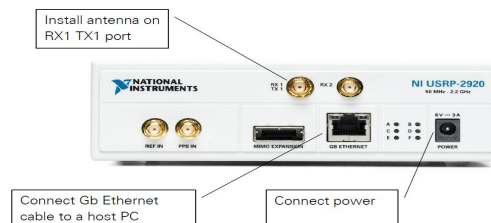


Figure 3:NI-USRP 2920 front panel

A Software-Defined Radio is a communication device where components that are typically implemented using hardware are defined in software and realized via programmable hardware. The implementation can be performed on general purpose computers or dedicated embedded systems. Some of the key characteristics of a SDR are multi-band antennas, wide-band RF converters, Digital-to-Analog Converters (DAC), Analog-toDigital Converters (ADC) and a

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general purpose processor to manage signal processing. This makes a software defined radio ideal in implementing dynamic spectrum access since it can operate in a wide range of frequencies, realize various modulation and coding schemes. Software defined radios allow us to vary the transmission characteristics on-the-fly based on the current RF occupancy and the state of the network.

USRP is widely used SDR platforms which possess various abilities of SDR, such as wide range of bandwidth and great tenability. USRP connects real-time RF systems to PCs using Universal Serial Bus (USB) or Ethernet connections. USRP was outlined and designed by Matt Ettus, who is the founded Ettus Research LLC, a National Instrument's company. Second generation USRPs are able to work with GNU radio, NI-Lab VIEW and Simulink. The USRP series under National Instrument's brand is called NI-USRP and are paired with NI-Labview tool boxes. NI USRPs are SDR prototype platforms capable of numerous applications for education and research.

The combination of NI's hardware and software offers flexibility and functionality for physical layer design, record and playback, signal intelligence, algorithm validation, and more in affordable price. In this project work NI-USRP 2920 is used, it has tunable center frequency from 50 MHz to 2.2 GHz covering FM radio, GPS, GSM, radar, and ISM bands. NI-USRP 2920 is connected to PC using Ethernet connection working in pair with NI-Lab VIEW and both are able to perform multiple input, multiple output (MIMO) functionalities.

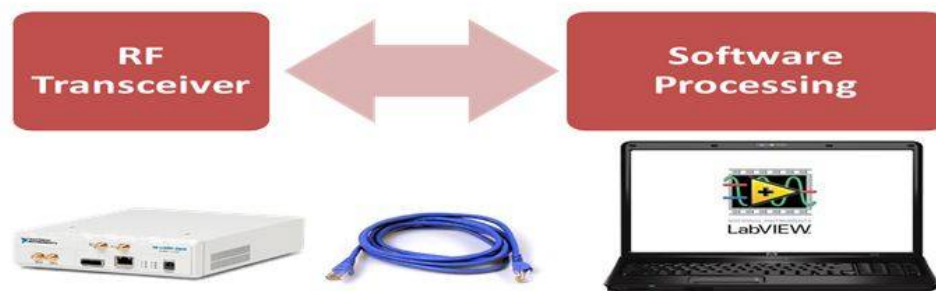


Figure 4: Interfacing NI-USRP kit with lab VIEW software for processing

The LabVIEW Communications System Design Suite offers a design environment closely integrated with NI software designed radio (SDR) hardware for rapidly prototyping communications systems..The USRP (Universal Software Radio Peripheral) is a flexible and affordable transceiver that turns a standard PC into a powerful wireless prototyping system. Paired with LabVIEW Communications System Design Software, USRP transceivers help you prototype a wide range of single-channel and MIMO wireless communications systems. The USRP and LabVIEW Communications System Design Suite offer a powerful solution for prototyping RF and communications systems. LabVIEW is a programming graphical language used which is much faster and easier way to implement the code on computer quickly.

VI. SYSTEM IMPLEMENTATION

The input data to be transmitted is generated by using the sine wave where at specific time intervals if the sample value is below threshold it is taken as digital data 0 and if above the threshold it is taken as digital data 1. The SNR value is taken for which the amplitude of the noise signal and power are calculated. The received data is obtained by adding the input data with the noise of obtained magnitude. The energy of the received signal is obtained by summing up the squared values of the samples. Threshold value of the energy is calculated by using the randomly generated values of P_f using gamma inverse function. If the detected energy value is greater than the threshold value, then it is considered as the correct value.

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Fig 5. shows the block diagram of continuous receiver where the the array of clusters is fetched from USRP Fetch block and FFT is taken to calculate the spectrum of the received array of data and compared with threshold for detection of primary user signal.

VII. RESULTS

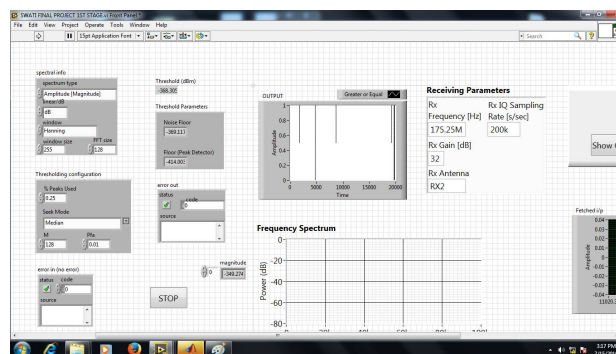


Figure 6: Spectrum Sensing using Energy Detection Method at 175.25MHz

Fig 6. Shows the sensing of spectrum using energy detection method in which the graph shows the comparator output where '1' represents that primary user is present and '0' shows that primary user is absent at that particular moment.

VIII.CONCLUSION

The spectrum occupancy evaluation from measurement clearly shows the TV band is underutilized, and digital switchover of TV transmission not only produce digital dividend, but also create opportunity for cognitive operation in TVWS in India. In this paper, primary user is identified by detecting the energy of received signal .The testing was done using NI USRP hardware devices and NI-Lab VIEW platform. We presented the measurement and the methodology to estimate the spectrum occupancy of TV band.

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