Development of a Low Power Indoor Transmission System with a Dedicated Android App

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Abstract- This Study demonstrates the design, development and the implementation of a low power, portable Indoor Transmission (campus radio) system using Raspberry Pi which facilitates larger scale implementation at moderate cost. It can be locally or remotely controlled and configured for both education and research purposes. This concept may be extended to implement in large college campuses or in any university by some parameter modifications where the latest happenings in an institute can be informed to the students by tuning to the pre-assigned frequency of an FM receiver system. For smart handling, a dedicated Android app is also developed here.

Index Terms- Antenna, FM, Receiver, RPi, Transmitter

I. INTRODUCTION

Campus radio is the communication system normally run by the students of an educational institution, college or even universities. Programs of this radio are generally anchored or performed exclusively by the students or may include programmers from the concerning community where the radio station is based on; while other radio stations exist to provide alternatives to commercial and/or government broadcastings [1-3]. This commercial-free college radio, generally focuses on art not dollar signs, may also be operated for the purpose of non-stop professional trainings, broadcasting educational programs, etc. It is just about being free and independent to pursue new ideas, providing content that isn't driven by the advertisers and that fits perfectly with the mandate of universities and their students. Also, college radio could be the launching pad for the student artists breaking into the mainstream. It is truly a place for discovery [4-5]. Nevertheless, only the commercial FM radio stations have been flourished in Bangladesh in last six-seven years; those are broadcasting different kind of programs, concerned only light entertainment and the whip of advertisers and vendors. Although they are bombarded with these uninformative commercial media, youths especially students of the country desperately rely on alternative information source and media like YouTube and online blogs. Campus radio could be the valuable alternative even in this age, like the decades back-long before this internet age. Realizing this, Sylhet Engineering College of Bangladesh launched the first ever campus based online radio system in February 2, 2010 [6]. Later ULAB (University of Liberal Arts of Bangladesh) started their Campus Radio (FM) Broadcasting System in October 16, 2011 [7] which is only available for Sun-Wed for a limited period of time (10-1:00). A 24×7 arrangement could have been a relief for the student youths of 16-25 year age.

Considering these significant factors, authors are motivated to revive a full-time campus radio system in Bangladesh perspective. Also a low-power, low-cost version was mandatory. This work, hence, develops a Raspberry Pi based campus radio system utilizing its advantages of low-power, low-cost and open-source easy configurations. Its small size (85.60 mm x 53.98 mm x 17 mm with 45g weight) helps to place in a simple case on a wall or to mount inside an electrical box with only a few feet long transmitter wire antenna. Some appropriate programs for this campus radio service are also proposed here considering their significance in academic level.

II. BACKGROUND STUDY

Raspberry Pi:

The Raspberry Pi (RPi) is a low cost, credit-card sized microcomputer developed by Raspberry Pi Foundation, UK [8] including standard keyboard and mouse interfacing facilities, and also can be plugged into a computer monitor or television. It is a tiny device that enables people of all ages to explore computing and/or programming in simple languages like Scratch and Python. This RPi has the ability to interact with the outside world, and has been used in a wide array of digital maker projects, from music machines and parent detectors to weather stations and tweeting birdhouses with infra-red cameras [8]. There are three available models of RPi in market: Model A, Model B and Model B+. The latest RPi Model B+ features the BCM2835 application processor with 512MB RAM, 40 pins GPIO header, 4 USB 2.0 ports, Micro SD card slot, 3.5mm audio jack, HDMI video output, camera connector slot [9] etc.

Raspberry Pi GPIOs:

External electronic devices can be interfaced with RPi through its dedicated GPIO (General Purpose Input/Output) pins which accept I/O commands from RPi. It is possible to store sensor data and manipulate relay or motors attached with GPIOs based upon the program running on the RPi's operating system. [10]

III. PROPOSED SYSTEM

Figure 1 illustrates the block diagram representation of the proposed RPi based campus radio system where a symbolic antenna is connected to GPIO pin-4 of RPi. Here the Pi transmitter uses its built-in sine wave generator which exhibits lots of harmonic distortion and appears as multiple transmissions in the FM band. The Raspberry Pi's broadcast frequency range is 1-250 MHz and it transmits any sound files through appropriate modulations. On the other side any wireless radio receiver system or mobile phone with FM facilities can be employed.

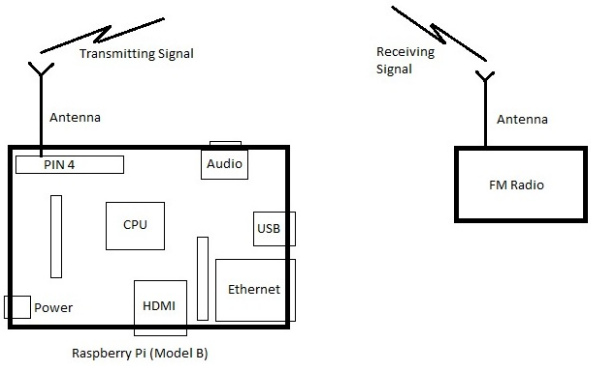

Figure 1: Block diagram of the proposed Raspberry Pi Based Campus Radio system.

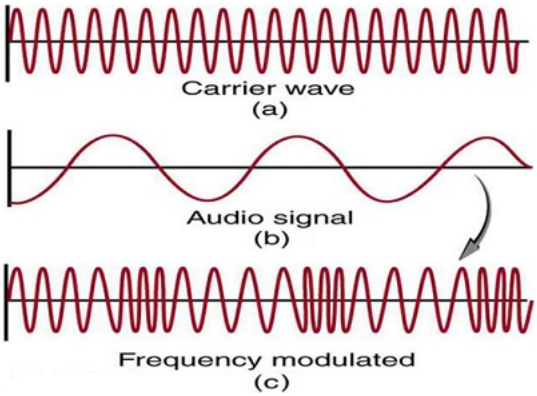

Figure 2: General FM modulation technique employed for RPi Transmission

Figure 2 shows the underlined FM modulation scheme where the first carrier wave is the RPi's internally generated spread-spectrum clock signal. Second modulating audio signal is the one which the radio system needs to broadcast. Last one is the FM modulated signal that would be available on the GPIO pin 4 to transmit though the antenna

A. Transmission Band Selection

Since there is a number of FM broadcasting channels in Bangladesh, the selection of transmission band of the proposed system is important to avoid the existing channel frequencies. The license of FM radio broadcasting is generally provided from the Ministry of Information, the government of Bangladesh. According to NFAP, frequency is assigned from BTRC to the licensee is from 87.5 to 108 MHz [15]. Table1 shows the existing 14 FM radio stations (January 2015) and their corresponding frequency bands [16]. Hence, the 103.0 MHz frequency band is selected for this system for the X University to avoid all kind of interference.

Table.1: The list of available FM radio stations of Bangladesh

Station Name	***Frequency Band (MHz)***	***Station Name***	***Frequency Band (MHz)***	***Station Name***	***Frequency Band (MHz)***
Radio Foorti	88.0 FM	Dhaka FM	90.4 FM	Radio Capital	94.8 FM
Radio Amar	88.4 FM	Asian Radio	90.8 FM	City FM	96.0 FM
Radio Metropolitan	88.8 FM	People's Radio	91.6 FM	BBC Bangla	100.0 FM
ABC Radio	89.2 FM	Radio Shadhin	92.4 FM	Color's FM	101.6 FM
Radio Today	89.6 FM	Radio Bhumi	92.8 FM		

B. Methodology

For large variations in locally available accessories with the original standards, the installation and/or configuration processes vary significantly from standard instructions [11]. The complete environment set up and arrangement of the system is done by following steps:

Step 1: To Prepare Raspberry pi for setup

To setup the RPi OS, the required apparatus are: Power Adapter (5V-700mA), HDMI lead: Type A to Type A (to connect with display monitor or TV), HDMI display or HDMI to VGA adapter for VGA display, SD card: 2 GB to 64 GB storage (8 GB used in this work and also minimum recommended for locally available SD cards); SD card reader, USB keyboard and mouse. For display purpose, it is recommended to use only LED monitors available in Bangladesh instead of local LCD monitors. Keyboard, mouse and LED monitors are not necessary later after the initial environment setup.

Step 2: Raspberry Pi OS installation

The software required for SD card formatter [SDF 16.0.0.400], Windows32 disk imager [win32DiskImager-0.9.5], Raspbspbian-weezy.iso. Considering its certain benefits, "*Raspbian*" OS is downloaded from [12]. After formatting the SD card using SD card formatter (FAT32), the *iso* image is burned to SD card using windows32 Disk imager. The details are omitted as the standard procedures of [11] are followed. The *config.txt* file is needed to edit by uncommenting (removing # sign): "hdmi_force_hotplug=1; hdmi_group=1; hdmi_mode=4; disable_overscan=0"

Step 3: Initial configuration for first boot

After expending the file system for using all the SD card space, the user password change is done. It is necessary to enable "*boot to desktop*" to "*directly boot to desktop*" and to enable *ssh* from the *advance* option.

Step 4: Network Configuration

For any remote access through/without internet, it is recommended here that the network should be configured as static rather than DHCP [13]. This network configuration is done

by providing following commands "*sudo nano /etc/networks/interfaces*" on terminal mode and setting up IP address, subnet musk and Gateway (for this work 192.168.0.103 with subnet 255.255.255.0 and 192.168.0.111 gateway, respectively).

Step 5: Audio Gadget Configuration

The Advanced Linux Sound Architecture (ALSA) is the underlying framework responsible for any sound stuff work on RPi. ALSA provides kernel drivers for RPi itself and for most USB gadgets that produce or record sound. The following command is needed to view the list of all connected audio devices (along with detailed status information) with ALSA: *"pi@raspberrypi~$ cat /proc/asound/cards"*. Also the startup of AlsaMixer is necessary to make sure the volume is loud enough to listen, using the following command: *"pi@raspberrypi~$ alsamixer"*. The *Up-Down* arrow keys of Keyboard can be used to adjust the volume meter and the *Esc* key to quit AlsaMixer.

Step 6: Pi-FM configuration

To install the *pifm* library, the following commands of *'wget'* are necessary after creation a directory *"pifm"* in download directory and 'tar' command to unzip the downloaded content:

"pi@raspberrypi~$ wget www.icrobotics.co.uk/wiki/images/c/c3/Pifm.tar.gz
pi@raspberrypi~$ tar –xzf Pifm.tar.gz"

Step 7: Finalizing Campus Radio

After successful installation of pifm, a sample transmission (at 103.0 MHz) of a sample music 'sound.wav' is checked by following commands: "*sudo ./pifm sound.wav 103.0"*. Any tuned FM radio receiver in the vicinity (1-2 meter) can receive this broadcasting.

Step 8: Antenna Customization

A simple piece of wire is enough for RPi FM transmitter antenna to cover a range of 50 meter under the restriction of BTRC [15]. For an optimal antenna, in this work, a 75cm female jumper wire is attached to pin 4 and insulated with the heat-shrink tubing (Fig.3). That would effectively make a half-wave dipole antenna at 100+ MHz, near the middle of the FM band. Dab hot glue around the soldered joint of pin 4 makes the antenna more rigid so that it can stand up better

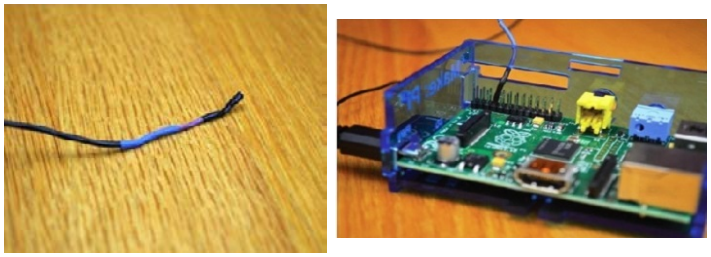

Figure 3 (a) Customized Antenna (b) Soldered antenna with GPIO pin 4 of RPi

Step 9: Development of an Android App "X University Campus Radio"

A dedicated android application "X University Campus Radio" is also developed here for both free program listening and smart management of the program scheduling. The authentic users need to log in (through/ without internet) by providing IP address of the RPi with the pre-assigned password and configure themselves as administrators. They can upload the 'to be broadcasted' programs and set the appropriate daily or weekly scheduling.

IV. Analysis and Discussion

The proposed campus Radio system has successfully been implemented and tested for the desired functionalities. The small size and low weight of RPi helps to place in a simple case or to mount inside an electrical box and to place on a wall in any administrative building room. Nevertheless, the control of these program schedules every day from the attached desktop or laptops sound clumsy in a country like Bangladesh where professional technicians are scarce, alternatives like user friendly mobile applications were always necessary. Besides, the drastic rise of the low price multi-featured smartphones with the introduction of 3G facilities in Bangladesh (November 2013) and preference of android phones by 93% smartphone users justifies the necessity of this dedicated Android app developed in this work.

As 95 per cent of the total internet users of Bangladesh (33.43 million in April 2013, 6.3% of the total population according BTRC) use the internet through mobile phones [14], an online version can also be implemented with some more features. Thus the campus radio will become the valuable alternative source of information.

V. Conclusion

This proposed campus radio system aims to serve particular student communities, informing, educating and entertaining them. In addition, this system should be sensitive, and respect the languages, traditions, beliefs and cultures of that community and also affordable to the community as people should be allowed to contribute what they can afford to help sustaining the station. This system can easily be adapted to any educational institutions without any need of professional administrator. Only it demands an endorsement of the Government and also the keenness of the institution individuals to accustom with this newer technology. Availability of RPi board and accessories in the local market is the major limitation for this massive employment.

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