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Enhancing Analog Radio Broadcasting Using DDRB Algorithm

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Abstract

With the rapid advancement of digital technology and the global transition toward modern radio broadcasting, Nepal has a significant opportunity to upgrade its radio broadcasting system. Digital radio services offer numerous benefits, including superior audio quality, broader coverage, interactive features, and enhanced capabilities. This thesis focuses on improving Nepal's analog radio broadcasting through the implementation of DDRB (Digital Radio Mondiale [DRM] Digital Radio Broadcasting) technology. The study begins by analyzing the current state of analog radio in Nepal, identifying its limitations and the challenges posed by the existing infrastructure. It then explores the technical principles and features of digital radio technology, assessing its suitability for Nepal's broadcasting environment. Based on the findings, the thesis proposes a comprehensive design for a DRM-integrated radio broadcasting system that can be seamlessly incorporated into Nepal's current infrastructure. The proposed design includes recommendations for transmitter specifications, network architecture, and content delivery mechanisms, with careful consideration of the geographical and demographic factors necessary for optimal coverage and accessibility across the country. The proposed system utilizing the DDRB algorithm aims to enhance the listening experience for audiences while enabling broadcasters to expand their services more efficiently and effectively.

Keywords: Digital Radio Mondiale (DRM), DRM digital radio broadcasting (DDRB), broadcasting, radio, audio

INTRODUCTION

The global shift from analog to digital radio broadcasting is transforming the way media and communication are delivered and consumed. For decades, radio has been a powerful tool for connecting communities, providing essential services such as news, entertainment, and cultural programming. The invention of radio has been credited to Guglielmo Marconi, Nikola Tesla, and Heinrich Hertz. Marconi's successful transmission of radio signals over long distances using electromagnetic waves were significant milestone in communication technology during this period [1, 2]. However, traditional analog radio faces significant challenges, including limited coverage, susceptibility to interference, and the inability to offer interactive or value-added services. With the advent of digital technologies like Digital Audio Broadcasting (DAB), Digital Radio Mondiale (DRM), and HD (high-definition) Radio, these limitations are being effectively addressed. These technologies offer superior audio quality, more efficient use of the radio spectrum, and the ability to broadcast multiple channels and data services on the same frequency band.

In today's digital era, radio is evolving far beyond its traditional format. It is increasingly incorporating

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multimedia features, providing listeners with an enriched experience that was not possible with analog systems. This shift is particularly impactful in countries like Nepal, where radio remains a crucial medium for communication. The integration of digital technologies, especially DRM, holds the potential to significantly enhance Nepal's broadcasting landscape. It promises to improve the quality of radio services, extend coverage to underserved and remote areas, and introduce interactive features that can engage listeners in new and dynamic ways. Moreover, digital radio can serve as a vital component of emergency communication systems, offering a reliable platform for the rapid dissemination of information during crises.

As the global trend toward digital radio broadcasting continues, the benefits are becoming increasingly clear. Enhanced audio quality, expanded programming options, and greater energy efficiency are just a few of the advantages that digital radio offers. This transition not only addresses the limitations of analog broadcasting but also aligns with the growing demand for more versatile and user-friendly media services. As countries around the world, including Nepal, adopt these digital technologies, radio broadcasting is poised to enter a new era of innovation and accessibility.

GENERAL THEORY

Digital Radio Mondiale (DRM) is an advanced digital broadcasting system specifically designed to transition from traditional analog to digital radio broadcasting. It is a globally standardized system that supports all broadcasting frequencies, including AM (amplitude modulation) bands (long wave [LW], medium wave [MW], short wave [SW]), as well as VHF (very high frequency) bands I, II (frequency modulation [FM] band), and III [3]. DRM leverages digital audio compression and coding to overcome the limitations of analog broadcasting while preserving its strengths. Importantly, DRM can operate within the same frequency allocations as analog transmissions and can utilize existing analog infrastructure, making it an ideal solution for developing countries like Nepal.

DRM operates in two main modes: DRM in the AM band and DRM in the VHF band which is shown in Figure 1. DRM AM, which covers broadcast frequencies below 30 MHz, provides extensive coverage across SW, MW, and LW bands. It offers FM-comparable sound quality, more reliable reception than analog AM, and the possibility of additional data services. Conversely, DRM+ operates in the VHF band, handling frequencies above 30 MHz [4]. It delivers surround sound with interactive channels and offers a range of value-added services. DRM+ is designed to fit within the FM broadcast band, efficiently using the available spectrum even in crowded bands.

DRM employs Coded Orthogonal Frequency Division Multiplexing (COFDM), where audio and data signals are digitally encoded and transmitted across numerous closely spaced carriers [5]. These carriers are kept within the transmitted channel, and time intervals are applied to mitigate fading.

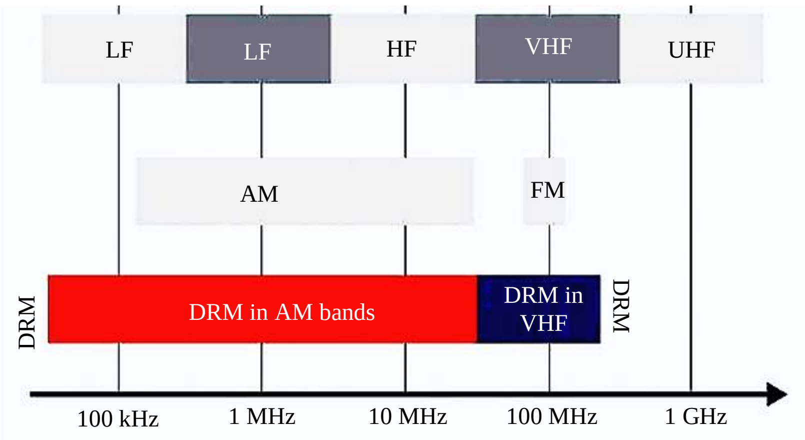

Figure 1. Frequency band spectrum.

The system's audio coding is based on MPEG xHE-AAC, a highly efficient compression standard that ensures high-quality audio at low data rates [6]. DRM supports a variety of multimedia services, including voice, text, images, and IP (internet protocol) streaming, making it a comprehensive solution for modern digital broadcasting.

EXPERIMENTAL SETUP

This paper describes the methodology for enhancing analog radio broadcasting using DRM digital radio broadcasting (DDRB) algorithm. A key focus was selecting DRM standards suitable for existing infrastructure, validated by aligning with international trends. Using insights from these observations, a new system design was developed for digital radio transmission in Nepal. The research explores the transition from analog to DRM-based DRB. A multidimensional experimental setup was employed to assess the technical feasibility, viability, and effectiveness of this technology. The experimental setup was conducted at Radio Nepal's broadcasting station in Kathmandu Valley, near Singh Durbar, to establish a transmitter setup with a content server capable of digital signal transmission. The DDRB algorithm enhances the analog radio services. It involves several steps and processes. The experimental design algorithm flowchart is shown in Figure 2.

Analyze the Existing Infrastructure

First, it is necessary to inspect the current analog FM transmission broadcast chain. Figure 3 shows the block diagram of existing analog FM radio broadcasting infrastructure system. The audio input source is coming from the studio. This audio is fed to the audio processor which improves the audio quality and consistency of audio. The output of the audio processor is fed to input of FM transmitter that accepts an audio signal and modulates it onto a high frequency carrier wave using FM. It then sends RF signal to the antenna to propagate the signal.

Primary Data Collection

The current state of radio broadcasting in Nepal is largely driven by analog FM transmission. The topology of the country is three different region such as Himalaya, Hilly and Tarai. So radio broadcaster is broadcasting FM radio from small power transmitter to maximum 10-kW transmitter power. While the transmission of FM radio they are using different types of transmitter model such as Eddy Stone, Gates Air, BE, RVR Electronica, and many more. These broadcasters use single bay, 2-bay, 4-bay, 6-bay, 8-bay dipole antenna, panel antenna with vertical and circular polarization. These RF signals are propagated in frequency spectrum 97.5 MHz–108 MHz in FM signal in band-II. Some of the FM transmitters are compatible for digital radio broadcasting. By adding one digital exgine card that is called modulator card to enrich for the transmission for digital signal propagation. Analog FM transmitter is shown in Table 1.

To perform a through observation of the existing analog FM radio broadcasting infrastructure used by Radio Nepal, several in-depth visits were undertaken by studio and transmitter facility inside the organization. The purpose of this observation was to collect data on the type of FM transmitter that was being used in analog FM broadcasting.

Observation of Existing Analog FM Transmitter

By observing various types of FM transmitter models, the first step is to analyze their compatibility with DRM technology for digital radio transmission within the existing FM band. Compatibility refers to the ability of these transmitters to propagate digital radio-frequency (RF) signals. Not every model of transmitter is necessarily compatible with DRM FM signal propagation, so it is important to select an appropriate transmitter capable of broadcasting a digital DRM FM signal. For this purpose, a digital modulator card needs to be installed inside the transmitter to manage the digital signal. The card takes the digital signal from the content server, modulates it, and converts it into an RF signal, which is then fed to the antenna for radio transmission. After analyzing the existing infrastructure, the evaluation of the transmitters' compatibility is shown in the Table 2.

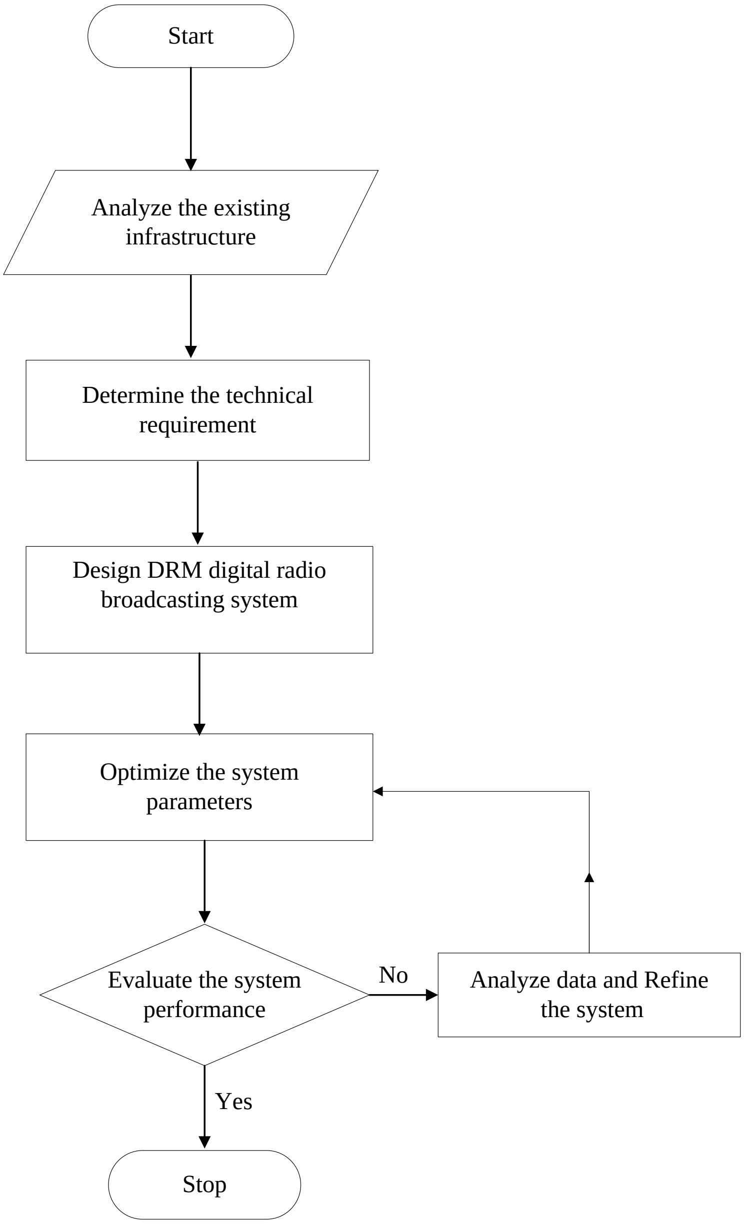

Figure 2. Digital radio mondiale digital radio broadcasting (DDRB) algorithm flowchart.

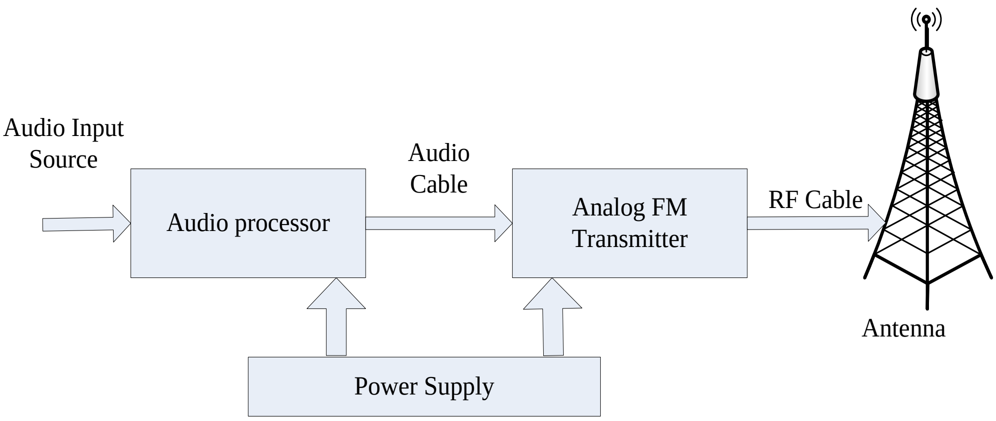

Figure 3. Block diagram of existing analog frequency modulation (FM) radio broadcasting infrastructure.

Table 1. Analog frequency modulation (FM) transmitter.

S.N.	Name of Transmitter	Quantity (Pcs)
1.	Gates Air	12
2.	RVR Electtronica	15
3.	BE	3
4.	Eddy Stone	5
5.	Electronica	2
6.	ST-100	1
7.	FP 100A	1
8.	B.W.	1

Table 2. Compatibility of existing frequency modulation (FM) transmitters with Digital Radio Mondiale (DRM) FM.

S.N.	Name of Transmitter	Quantity (Pcs)
1.	Gates Air	12
2.	RVR Electtronica	15
3.	BE	3
4.	Eddy Stone	5

Table 3. Technical requirements of Digital Radio Mondiale (DRM) frequency modulation (FM).

Parameters	Values/Specification
Net MSC data rate	37-186Kbps
Audio coding	MPEG4 AAC+
Number of channels	1–4
Symbol duration without guard interval	2.25 ms
Guard interval duration per symbol	0.25 ms
Number of carriers per symbol	213
Subcarrier spacing	444 4/9 Hz
TF duration	100 ms
Number of symbols per transmission (TF)	40
Number of TFs per transmission super frame	4
Subcarrier modulation	4/16 QAM
RF system bandwidth	96 kHz

Determine Technical Requirements

Identify the technical requirements for digital radio broadcasting using DRM plus technology. This includes signal encoding, modulation techniques, error correction, and transmission planning, while considering the specific needs and challenges of the broadcasting landscape. This type of technical data can be collected by publications, ITU recommendation and DRM consortium handbook and known as secondary data.

Secondary Data Collection

Extensive research was done to collect in the information about the specific value for technical requirements used by DRM digital radio broadcasting technology to analyze the challenge to adopt modulation and error protection ratio (Mod-Code) according to geographical topology of Nepal in mode E that is referred by DRM FM [7]. The key technical parameters of DRM-based DRB is shown in Table 3 [8, 9].

Design of DRM Digital Radio Broadcasting System

By using the DRM digital broadcasting phenomenon and consideration, the digital broadcasting system has been designed in such a way that there are two parts: one is studio part containing content-server and second is transmitter part including transmitter with digital exgine card put inside the transmitter. And these two sections are connected by a single network.

Figure 4 show the DRM based digital radio transmission system. In this scenario, three numbers of audio channels and one data channel are fed from the studio to the content server. The content server is a central system which has capability to storing and managing the content that is broadcast over digital radio station. Here the content means the audio stream, metadata, advertisement and other multimedia elements. Whereas the Messaging Multiplexor (MMP) server is used for web audio streaming purpose for internet reachable device. This content server encapsulates multimedia content and provides medium-dependent interface (MDI)/digital cinema package (DCP) output. This MDI output is fed to the DRM exgine card which is kept inside the compatible transmitter slot via LAN cable. Where this exgine card makes digital modulation process and give the RF output to the transmitter to transmit this digital signal to the antenna system input. In this way, these signals can be propagated via antenna system. Whereas laptop is used for configuration of content server, MMP server and engine card are used for suitable transmission of digital radio. Content server configuration is shown in Figure 5.

Optimize the System Parameters

There are two parameters to optimize the system. One is channel parameter and another one is channel capacity. In the channel parameters there are various components such as robustness mode E for FM band, Mass Storage Class (MSC) mode (16 QAM, 4 QAM), protection level (EEP and UEP). The channel parameter includes maximum bitrates. In MSC 16 QAM there are two level of protection level (PL) that is higher protection level (HPL) and lower protection level (LPL). So, there are tradeoffs between HPL lower bit rate and LPL higher bit rate. That defines the number of channels. By varying these parameters increases coverage area, improve audio quality and reception reliability at constant transmitter power and frequency. Also, coverage area can be increases by placement antenna. Table 4 shows the data rate of MSC in 16 QAM and 4 QAM in different PL of equal error protection (EEP). Where HPL lower bit rate is PL = 0 (0.33), LPL higher bit rate is PL = 3 (0.62) and moderate protection level bit rate is PL = 2 (0.5).

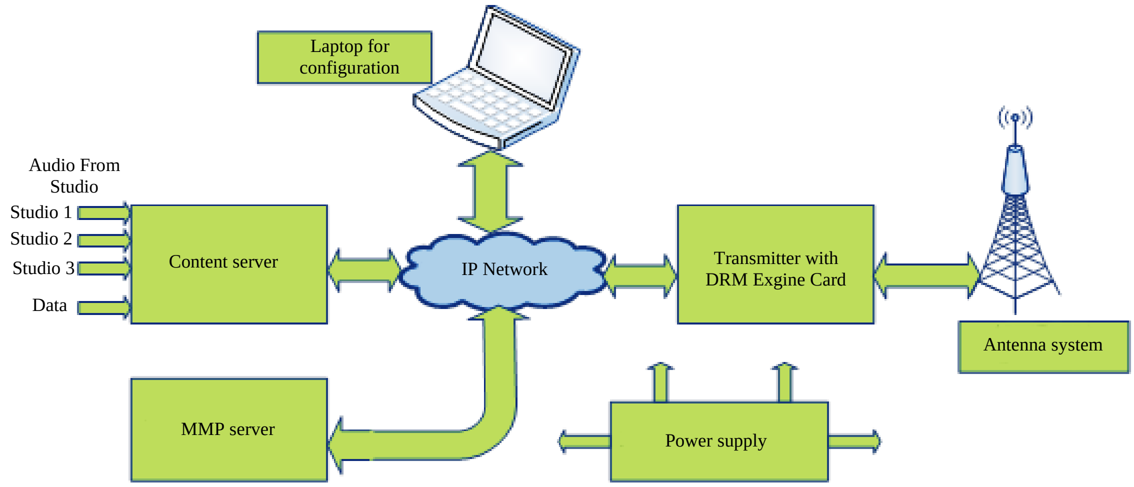

Figure 4. Design of Digital Radio Mondiale (DRM) digital radio broadcasting system.

Table 4. Mass Storage Class (MSC) configuration according to protection level.

MSC	Higher Protection Lower Bitrate	Lower Protection Higher Bitrate	Moderate Protection Moderate Bitrate
16 QAM	99.36 Kbps	186.32 Kbps	149.04 Kbps
4 QAM	37.2 Kbps	74.48 Kbps	59.6 Kbps

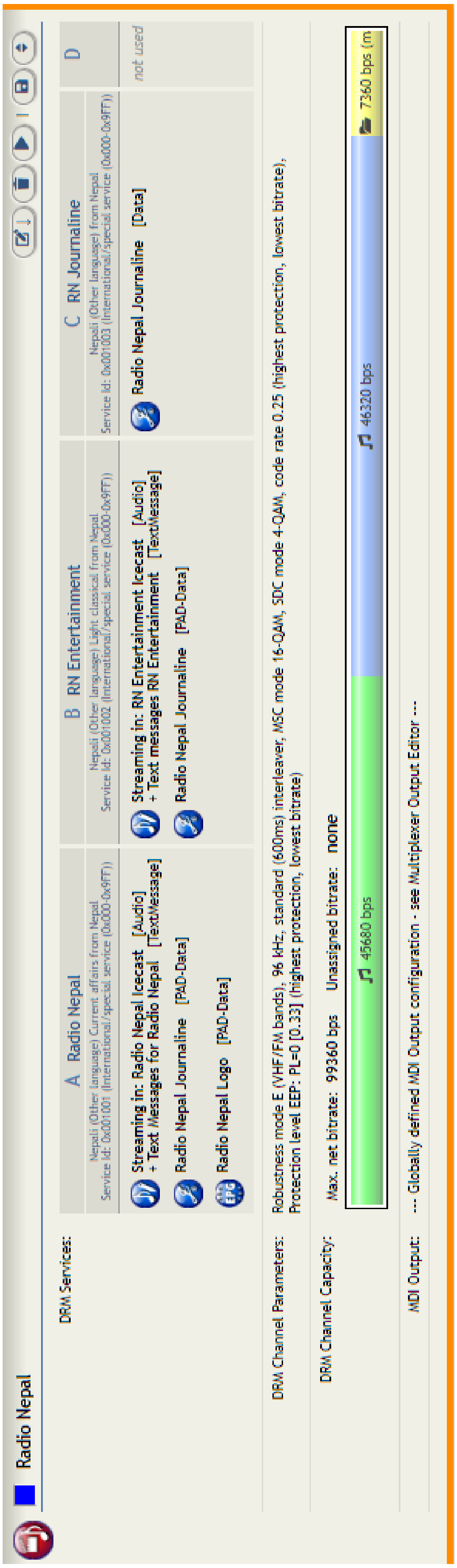

Figure 5. Content server configuration.

Evaluated System Performance

The evaluation of system performance can be evaluated by digital radio receiver by conducting field measurement of signal quality. This means the signal reception quality, coverage area and receiver performance. Thus, system performance can be measured by comparing the digital signal with existing analog FM signal.

RESULTS AND DISCUSSION

This section presents a comparative analysis and discussion of the collected results, offering insights into the implications and interpretations drawn from the data. The experimental design methodology was employed to adjust the technical parameters of the content server and transmitter to assess the impact of various factors on audio signal quality, the number of services, geographical coverage, and transmitter power. These responses were analyzed using a DRM digital receiver, highlighting the challenges of integrating DRM technology into the existing analog radio broadcasting system to enable digital signal transmission. When developing a new digital radio broadcasting system, several criteria must be met, with budget being a crucial factor. The primary goal is to leverage the existing analog broadcasting infrastructure to transition to digital terrestrial radio transmission, thereby enhancing audio services while minimizing costs. This approach reduces expenses by reusing the existing system rather than introducing an entirely new setup. Integrating DRM requires minimal infrastructure modifications specifically, adding a content server at the studio site and installing an exgine card (DRM modulator card) in a compatible transmitter. These are the necessary and sufficient conditions to create the digital transmission network.

At the studio site, the content server is installed on a standard hardware PC and configured appropriately. The audio signal data rates and the number of channels are managed within the content server. As shown in Figures 5 and 6, after integrating DRM into the existing analog FM transmitter, two audio channels (Radio Nepal and RN Entertainment) and one data channel are broadcast on a single frequency of 106.3 MHz.

The result of installing the exgine card (modulator card) in the existing analog transmitter demonstrates that the frequency spectrum is utilized more efficiently. The transmitter can also be configured in appropriate format as transmitter power, frequency, RF sample in radio transmitter form is shown in Figure 7.

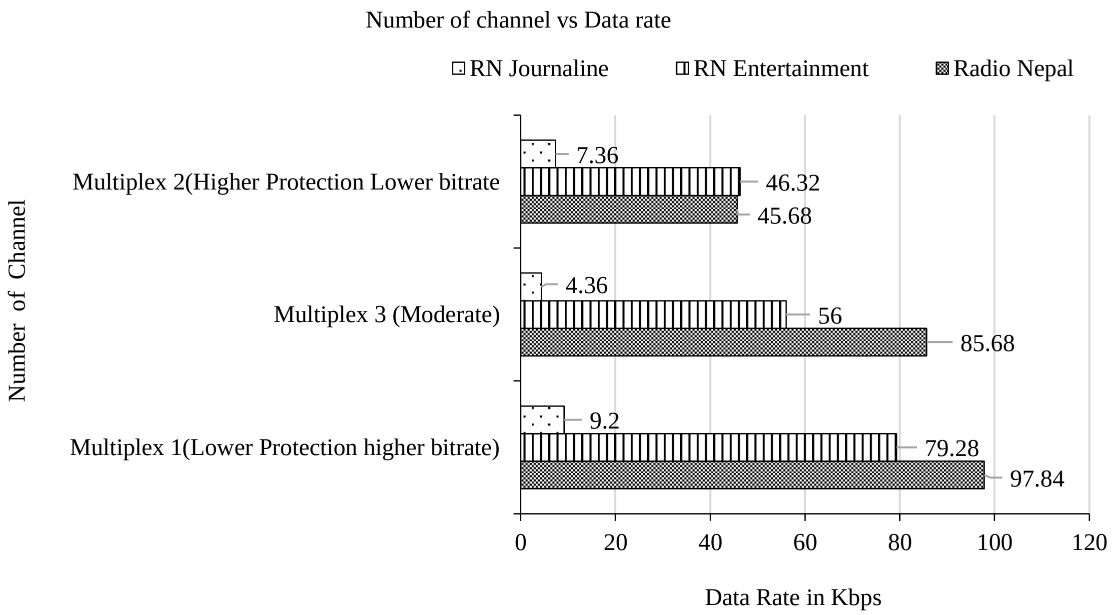

Figure 6. Number of channels versus data rate.

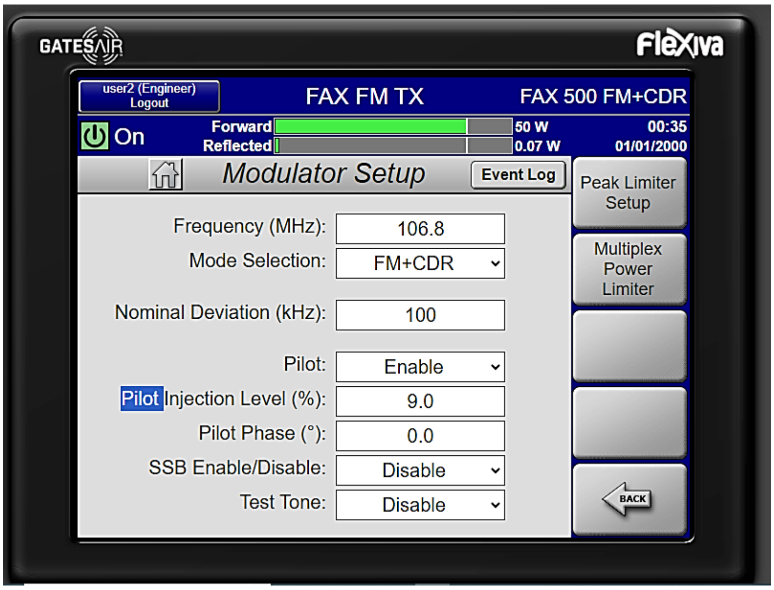

Figure 7. Transmitter modulator.

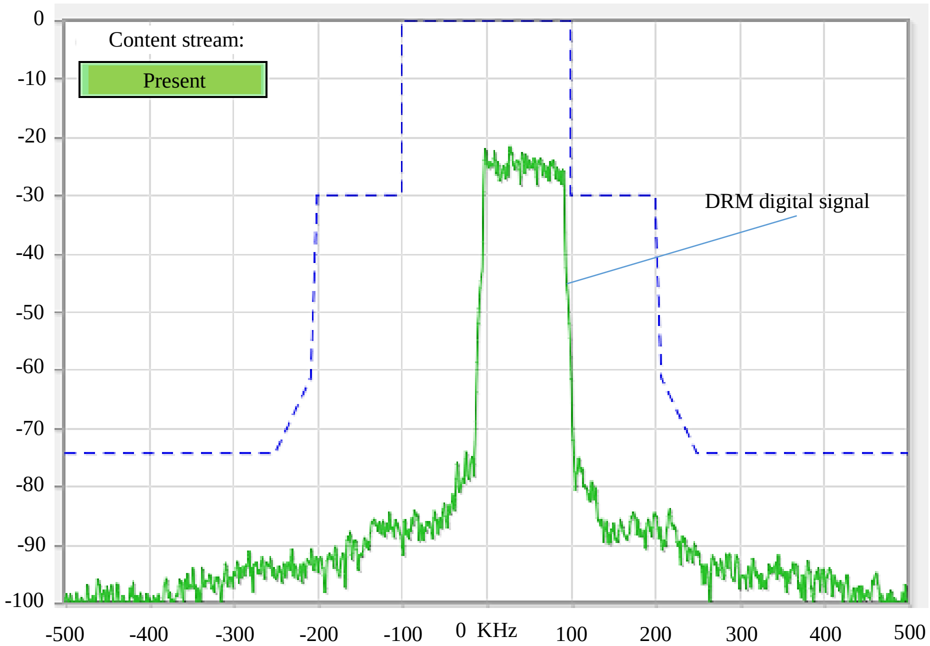

Figure 8. Digital Radio Mondiale (DRM) frequency modulation (FM) digital signal frequency spectrum.

Therefore, the frequency spectrum of DRM FM digital radio is 100 kHz, which is less bandwidth than traditional analog radio broadcasting as shown in Figure 8.

CONCLUSION

The implementation of the DDRB algorithm in analog radio broadcasting provides an opportunity to fully utilize the existing analog transmitter infrastructure, paving the way for a cost-effective transition to digital broadcasting. By integrating this advanced technology, significant improvements can be made in audio quality, resulting in clearer and more immersive sound for listeners. Additionally, the DDRB algorithm expands the number of available channels, allowing broadcasters to offer a more diverse range of programming options tailored to audience preferences. Moreover, the introduction of interactive features enhances listener engagement, making the overall experience more enjoyable and participatory. Another key advantage of DDRB technology is its capacity to ensure a more efficient use of spectrum bandwidth, which is a vital resource in the broadcasting industry. This increased efficiency allows for the delivery of a greater volume of content within the same frequency range, thereby maximizing the potential of the broadcasting infrastructure. Ultimately, the transition from an analog to a digital system not only modernizes broadcasting capabilities but also significantly enriches the listener experience, ensuring that audiences receive high-quality audio and a wider array of programming options.

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