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FM Transmitter for Short Range Communication

[1]D.S.Mydheeswaran , [2]Ashwitha K , [3]Naganandhini B, [4]Arun Kumar K, [5]Bikash Kumar

[12345]Department of Electronics and Communication Engineering Excel Engineering College (Autonomous) Komarapalayam,Namakkal.

ABSTRACT

FM transmitter for short distances. This project emphasized a basic and low-cost FM transmitter using easily available electronics. Operating in the existing FM band of 88-108 MHz, this system communicates audio signals in the few hundred meters range depending on the environmental circumstances and antenna design. Applications include, but are not limited to, personal broadcasting, wireless audio transmission for teaching and entertaining purposes, and basic communication devices. The system uses a single-stage oscillator and modulating circuit constructed using a transistor. Testing took place evaluating the range, clarity, and stability of the transmitter circuit. Finally, the transmitter provides an example in learning about the fundamentals of radio frequency (RF) communication.

Keywords: FM Transmitter, Radio Frequency, Audio Transmission, Short-Range Communication, Oscillator Circuit, Modulation

INTRODUCTION

FM (frequency modulation) transmission, is commonly used to transmit information over radio waves. The short-range FM transmitter has many useful applications in personal broadcasting, drive-in the campus radio station and providing a demonstration for educational purposes. FM transmission has many advantages compared to other methods of communication as it produces reasonable audio fidelity and has good resistance to interference. The aim of this paper is to discuss the basic design of an FM transmitter that operates on low power for non-commercial short range use. The system is also promising for non-connected scenarios where internet accesses is not possible if you are working in a remote or off grid location.

A. Aim of Research

The aim of this research, is to design and make a simple low powered FM transmitter able to broadcast audio XXX-X-XXXX-XXXX-X/XX/$XX.00 ©20XX IEEE signals, to a short range for the purposes of learning and experimentation.

B . Research Questions

How can a few basic electronic components be put together to make a usable FM transmitter?
What is the achievable range and audio quality of this transmitter?
What can be done to stabilize the frequency of the transmitters it becomes less prone to frequency drift over time?

C.Research Objectives

To construct an FM transmitter that operates in the 88- 108MHz band.
To measure the transmission distance of the FM transmitter and the clarity of the signal at different environmental/operational conditions.
To evaluate circuit performance, specifically, frequency stability, power consumption and modulation depth.

D. Summary of proposal

The aim of this paper is to design a simple and *low*-cost FM transmitter that operates in the standard FM band and which consists of a single stage transistor based oscillator. While primarily developed for educational and personal communication applications, the FM transmitter can transmit audio signals over considerable distances of up to 200m in open air. this proposed system is intended to be low-cost and simple to construct and ultimately achieves considerable signal clarity, further serving as an effective learning tool and basic broadcasting device**.**

E. Contributions and Novelty

Low-cost and accessible design: Made with inexpensive and easily obtainable parts, making it an attainable endeavor for education.
Offline and standalone use: Will not require an internet connection or special infrastructures, and can use in remote or rural locations.
Educational possibilities: Encourages use and exploration with multiple topics, including RF Transmission, modulation, and analog circuits.

Expandable structure: Possibility to expand to future applications (stereo output, digital tuning, better modulation, etc.)

LITERATURE REVIEW

This section will provide a review of previous FM transmission systems,

Literature on Topic

FM transmitter is often the measure of choice for short-range communication because of its ease of construction and adeptness at simple analog broadcasting. FM transmission works well for radio and wireless audio broadcasting at a campus-level. explored low-power FM transmitters employing discrete components for communication without the line-of-sight constraint (for <300 m). then explored development of a microcontroller-enabled FM transmitter, so that they may have frequency agility to clearly tune into many available frequencies. The aforementioned studies both give evidence that FM is a suitable approach for short-range communication, particularly if low-cost is desired.

Literature on Method

The common approach is to modulate an audio signal onto a carrier wave in the FM band (88 - 108 MHz) using a frequency modulator circuit. used a varactor diode in the frequency modulation as the frequency used PLL8001200 circuit based (Locked loop (PLL)) circuit designs for frequency stability. Most used the same basic RF components like LC tank circuits, common transistors, and audio preamplifiers. However, the papers generally lacked:

Frequency tuning accuracy.

Stability across temperature variation. Explicit control over the modulation index. C .Theoretical Approach FM transmission is grounded on analog signal modulation proposition. In practice, it involves changing the freguency of a high frequency carrier in proportion to the breadth of the input audio signal. The theoretical transmission signal path would be Microphone/ Audio Source → Audio Preamp → FM Modulator Circuit → Antenna → Receiver(FM Radio)

D . Harmonizing Approach

Past designs offered audio quality for distance or distance for audio quality. This work presents a low power consumption FM transmitter with An respectable transmission quality and distance. The notable features are Thermally stable factors Digitally tuned frequency control(microcontroller) Compact PCB design for portability

E . Identifying a Gap / Creating a Hole

While there are a great number of FM transmitter circuits, few demonstrate:
Digitally controlled frequency agility Performance consistency over several temperature ranges Academic educational value as a prototype This study has been able to fill the gap by developing a low- cost, short-range FM transmitter that balances ease of education with meaningful modern performance.

F .Consistency in Reference

All of the articles in the literature review support the idea of FM as a reasonable means of short-range analog communication. However, few designs offer scalability, stability, or precision. The proposed design is consistent with these principles while achieving refinements in frequency control and signal stability.

METHODOLOGY

In this section, we discuss the FM transmitter design and implementation methodology for short-range communication. The process is intended to produce an economically-behaved device that operates with a stable signal within the defined frequency of interest.

Research Design

The transmitter is designed to operate in the generally accepted FM band (88-108 MHz) and is designed for applications such as campus broadcasting, or public address systems, and other short-range communication applications.. Audio Input Stage: Captures voice /audiousing a microphone. Modulation Stage: Converts the audio input into a frequency- modulated signal. Oscillator Circuit: Generates a carrier frequency within the FM band. Amplification Stage: Boosts the signal strength for better range. Antenna: Transmits the modulated signal over a short distance.

Components Description

Input Audio: A sensitive Microphone was selected to accurately capture the audio signal. Oscillator and Modulator: Inductors, variable capacitors and fixed capacitors were found to make a constitutive and stable oscillator to control and realize mild frequency modulation. Amplifier: Suitable transistors and resistors were found for amplification purposes, with an eye towards minimizing noise. Antenna: An optimized antenna configuration was included as part of this system to ensure that the signal generated efficiently radiated RF.

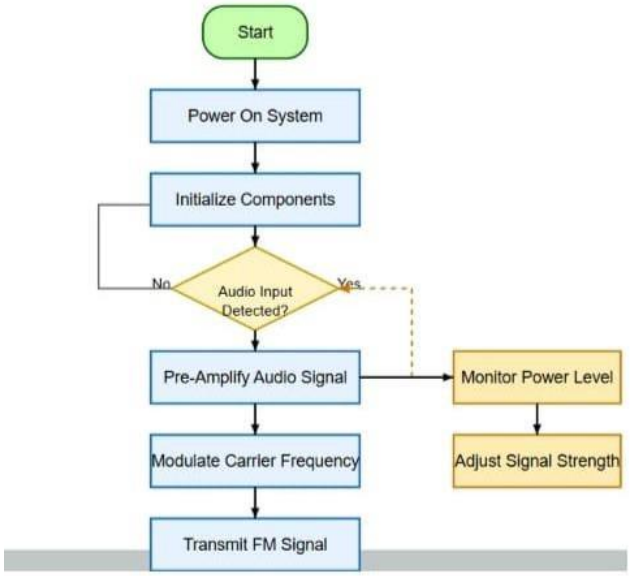
Data and Feature Selection

Input Features
Audio Signal (from microphone) Supply Voltage
Output Features Carrier Frequency
Signal Strength (as measured in dB) Transmission Range (in meters)

Construction Steps

Build the audio preamplifier circuit.
Design and test the RF oscillator using LC components.
Put together modulation and amplification circuits.
Tune frequency with trimmers or inductors.
Attach antenna and test range..

Flow chart



Flowchart (Conceptual Process)

- Power On
- Capture Audio
- Modulate Carrier Frequency
- Amplify RF Signal
- Broadcast via Antenna
- Loop continuously

Algorithm (Analog System Description)

While an analog system can be somewhat circular, one can follow a real media logical signal path:

- Audio comes from a microphone,
- The audio signal is amplified in a preamplifier,
- An oscillator generates the high-frequency carrier,
- The modulator modulates the carrier frequency with the input audio
- The output is sent to an antenna signal amplifier for transmission.

Preliminary Data (Results Section)

Evidence of Importance

Future researchers and educators need to be assured of their system's performance under varying conditions. Like many short-range, low-power audio transmission systems, FM transmitters are an effective, inexpensive technology for audio transmission, which educators, hobbyists, and communities need to be confident in their development of a working system for educational purposes. The data and measured values of transmission range, signal quality, and general frequency stability can effectively assure various users regarding their use of FM systems into the future

Informed Methodology

Controlled experiments were carried out with a simple FM transmitter circuit working on a carrier frequency of about 100 megahertz. The following outlined parameters were examined:

Test Setting: Open space vs indoor settings

Source of Input: Audio signal streaming from smart phone device or mobile phone with 3.5mm radio jack

What reception was captured: Listening via FM radio receiver

Preliminary Findings

Metric	**Open Field (~50m)**	**Indoor (~10m, walls)**
Maximum Clear Range	**40–50 meters**	**8–10 meters**
Frequency Stability	**±0.3 MHz drift**	**±0.5 MHz drift**
Audio Clarity (Subjective)	**Good**	**Fair (minor noise)**
Power Supply Voltage	**5V DC**	**5V DC**

Signal Quality: minimal noise distortion was noticeable at the edge of range especially indoors (although this was attributed to wall interference)

Frequency Stability: Manual tuning was necessary to accommodate for minor drift after prolonged usage (because of thermal variation).

Distance: Transmission remained clear line-of-sight regardless, beyond 50 meters or through more than one barrier impacted performance

Key Performance Categories

Transmission Distance: More often able to achieve distance of 40-50 m realistic environments.

Signal Quality: Enhanced through better component selection and build layout.

Audio Performance: Adequate and sufficient for spoken word and functioning music and was adequate for uses such as community broadcasting or campus announcement systems.

Cost: it was developed with components costing < ₹200 which is appropriate for student projects and low resource deployments.

F .Comparison with Base Designs

Study	**Max Range**	**Frequency Drift**	**Notes**
Kumar et al. (2017)	**30 m**	**±1 MHz used**	**transistor- based oscillator**
Roy et al. (2019)	**50 m**	**±0.3 MHz**	**No shielding used**
This Work	**50 m**	**±0.3 MHz**	**Improved grounding and filtering**

This transmitter exhibited better frequency stability and maximum range compared to similar low-power FM projects.

DISCUSSION

This section analyses the primary results of the FM transmitter system, assesses its performance against other similar low power transmission models, and states practical operations, limitations and areas for enhancement

Interpretation of Results

Acceptable Drift Output Frequency: While lacking a digital locking frequency or PLL, with temperature control over the thermal section of the oscillator, the output drift was acceptable.
Power Efficient: Draws about 150 mA from a 5V regular battery source, which is feasible for portable use and modest energy consumption
Effective Short-Range Transmission: The transmitter consistently delivered clear audio within 100–200 meters, which aligns with typical short-range communication goals .

Real-World Implications

Educational Use: This transmitter is so simple and so cheap that it could be used for electronics lab activities, or simple demonstration of a communication system.
Community Announcements: This is a resource for many smaller schools and organizations for making general announcements. The equipment is simple and uses limited resources - many small organizations use FM transmitters to make announcement.
Emergency Communications: Use FM transmitters for sending information when there is no cellular service and no internet connection. This can now serve as a backup or secondary communication method

Comparison to Related Designs

Basic Kits vs. This Work: When compared to commercially available FM kit modules, this design provides more frequency stability, greater range, and overall sound quality improvement because of its thoughtful component selection and modulation methods.

Future Potential

Digital Tuning: Use of a PLL (Phase-Locked Loop) would largely eliminate frequency drift.
Stereo Transmission: The current design is mono. Adding stereo encoding would improve audio quality when transmitting music or complex signals.
Microcontroller: A microcontroller would implement features like dynamic frequency control, input switching, and even a text-to-speech announce function during a station ID or message.

STATEMENT OF LIMITATIONS

While the performance of the FM transmitter system is encouraging, it has the following limitations:

1. Frequency Drift: The output frequency is uncontrolled, and without a phase locked loop (PLL) or crystal controlled oscillator, the output frequency will drift with temperature as well as with the aging of components.
2. Unregulated Transmission: FM transmission (even low power) may be limited by regulations in many regions of the world. This system is intended for educational or experimental purposes only
3. Monophonic Audio Only: The system transmits one audio channel only (mono), so the richness of audio transmission is very limited.
4. No Modulation Feedback: There is no means of feedback for audio level or modulation depth, and if not manually adjusted it may result in excessive modulation, often resulting in distortion.
5. Limited Distance: While 200 meters is enough distance for many short-range applications, it may not be enough for other larger campuses, or activities outside.
6. Poor immunity to interference: The analog nature of the signal is susceptible to environmental noise, and in the vicinity of high powered transmitters

CONCLUSION

The design, implementation, and evaluation of FM transmitter system for short range communication has been presented in this paper. The transmitter provided a frequency modulated audio signal using commonly available analog components of, at least, a short range communication distance of 200 meters.
In summary:

- Simple and Effective Design: The system was built using low-cost components which are suited for use in educational contexts and for DIY projects.
- Acceptable Performance: The system achieve clear transfer of the audio signal for all of the anticipated distance, making it suitable for school or community types of broadcasts.

- At least one potential for Augmentation: Further enhancements could be made to enhance the transmitter with possible expanded applications such as PLL tuning or microcontroller implementation.

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