

# Inductive Data Transmission System using FSK Modulation

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**Abstract:** Inductive data transmission provides an effective alternative to traditional wireless communication methods such as radio frequency (RF) or infrared (IR), especially in environments where electromagnetic interference, physical obstructions, safety regulations, or metallic enclosures limit their use. This paper presents the design, implementation, and evaluation of an Inductive Data Transmission System capable of transmitting short, secure digital messages using magnetic induction in the low frequency band of 65–135 kHz. The proposed system uses Amplitude Shift Keying (ASK) and Frequency Shift Keying (FSK) as suitable modulation schemes for inductive communication. The system is intended for communication between two isolated devices, such as a moving vehicle and a stationary unit, without requiring physical contact. Experimental results demonstrate that the system achieves reliable data transmission within a defined proximity range while maintaining electrical isolation and robustness against environmental noise. The study highlights the potential of inductive data exchange for automotive, industrial, biomedical, and access control applications.

**Keywords:** FSK, Modulation, Inductive data transmission, ASK, Radio frequency (RF) or Infrared (IR), Amplitude Shift Keying, Frequency Shift Keying, infrared, IR, RF.

## I. INTRODUCTION

Wireless communication is widely used for data transmission, but not all environments are conducive to traditional RF or IR techniques. Metallic structures, underground installations, safety critical locations, and electrically noisy environments often require alternative communication solutions. Inductive communication, which uses magnetic field coupling instead of radiated electromagnetic waves, provides a highly reliable method for short range, isolated data transfer.

Inductive data transmission operates on the principle of electromagnetic induction, where a time varying magnetic field generated by a transmitting coil induces an electrical signal in a receiving coil positioned nearby. Unlike RF communication, the near field coupling ensures that the energy remains localized, reducing the impact of interference and eavesdropping. This makes inductive systems ideal for vehicle to infrastructure communication, secure access systems, near field sensors, and embedded electronics that require galvanic isolation.

This research focuses on designing an inductive communication system optimized for low frequency operation between 65 and 135 kHz. Such frequencies offer stable magnetic coupling, low attenuation, and compliance with industrial standards.

## II. RELATED WORK

Inductive data transmission has been applied in several domains such as RFID systems, contactless payment devices, biomedical implants, and automotive identification systems. Near Field Communication (NFC) standards also rely on magnetic induction but operate at higher frequencies (typically 13.56 MHz). Previous studies highlight the benefits of low frequency inductive coupling for environments where metal presence dampens high frequency signals. This work expands on such studies by focusing on a custom inductive communication link designed for vehicle to stationary data exchange, where movement, isolation, and reliability are key concerns.

## III. PROPOSED METHODOLOGY

The proposed inductive data transmission system enables safe, short range wireless communication between two physically isolated devices. It operates using the following principles:

### 3.1 Electromagnetic Induction

A transmitting coil driven by an alternating current produces a time varying magnetic field. A receiving coil placed within this field induces a voltage proportional to the mutual inductance and the rate of change of current.

### 3.2 Modulation Technique

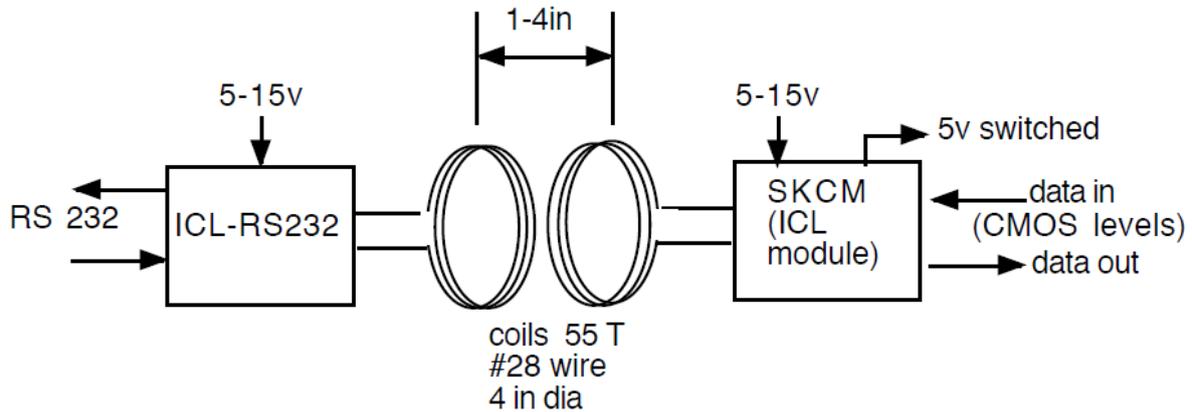


Figure 1: Transmitter and Receiver Block Diagram

The system supports both ASK and FSK modulation schemes:

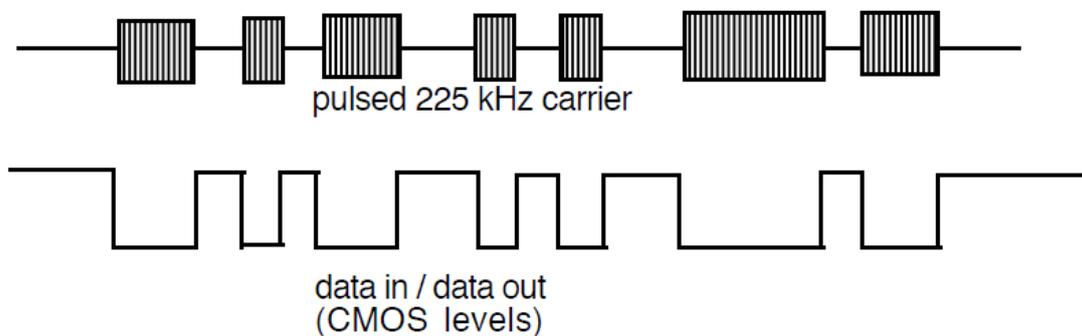


Figure 2: Modulation Signals

ASK: Simple to implement; suitable for low data rate transmissions.

FSK: More robust against noise and distortion caused by coil misalignment or movement.

### 3.3 Short Message Protocol

To maintain reliability, the transmitted data is structured into short packets with error checking codes, start/stop bits, and data framing.

### 3.4 Isolation and Safety

There is no direct electrical connection between transmitter and receiver. Isolation ensures the system remains unaffected by ground loops, voltage differences, or electrical noise.



## IV. HARDWARE DESCRIPTION

### 4.1 Transmitting Section

The transmitter consists of:

Microcontroller: Generates digital data and controls modulation.

Modulator Circuit: Converts binary data into ASK or FSK signals.

Power Driver: Amplifies the signal to energize the coil.

Transmitter Inductive Coil: Custom wound ferrite core or air core coil tuned to the operating frequency.

### 4.2 Receiving Section

The receiving unit includes:

Receiving Coil: Captures magnetic energy and induces voltage.

Signal Conditioning Stage: Includes filtering, amplification, and demodulation.

Demodulator: Extracts digital data from the received ASK/FSK signal.

Microcontroller: Processes decoded data, verifies integrity, and outputs the message.

### 4.3 Operating Frequency Band (65–135 kHz)

This band is chosen because:

- It provides efficient inductive coupling.
- It has low electromagnetic interference.
- It is suitable for near field communication and meets industrial standards.

## V. SYSTEM ARCHITECTURE

The system architecture consists of:

1. Data Source and Encoder
2. Modulation and Transmission
3. Magnetic Induction Coupling
4. Demodulation and Decoding
5. Output Data Processing





### 6.1 Coil Design and Tuning

The inductive coils were designed using Litz wire to minimize skin effect losses at the chosen frequencies. A resonance capacitor was added to tune the coil to the desired operating frequency for enhanced efficiency.

### 6.2 Modulation Implementation

ASK was implemented using microcontroller PWM output with amplitude switching.

FSK was implemented using two distinct frequencies generated through timer modules.

### 6.3 Signal Conditioning

Band pass filters were designed to attenuate noise outside the 65–135 kHz range. Precision operational amplifiers ensured clean demodulation.

### 6.4 Prototype Testing

Tests were conducted on:

- Transmission distance
- Coil alignment sensitivity
- Data error rate under motion
- Noise performance near electrical equipment

## VII. RESULTS AND DISCUSSION

### 7.1 Transmission Range

The system achieved reliable communication within 10–25 cm, depending on coil size and alignment.

### 7.2 Data Integrity

With FSK modulation, the biterror rate (BER) reduced significantly compared to ASK, especially during movement.

### 7.3 Effect of Coil Misalignment

Horizontal or angular misalignment reduced the induced voltage but did not interrupt communication until beyond a threshold. FSK remained more stable.

### 7.4 Environmental Performance

Unlike RF communication, metallic surroundings had minimal effect on the inductive link due to the nearfield nature of magnetic coupling.

### 7.5 Suitability for Vehicle Applications

The prototype successfully demonstrated communication between a moving transmitter and a stationary receiver, validating its use in vehicle identification, toll systems, and parking automation.



## Applications

The developed system is suitable for:

- Vehicle to gate communication
- Smart toll collection
- Automated parking systems
- Industrial sensor monitoring
- Biomedical implants
- Secure access control
- Underground or metallic environments

## VIII. CONCLUSION

This research demonstrates that inductive data transmission provides a robust and secure alternative to traditional wireless communication techniques in short range applications. Operating within the 65–135 kHz band, the system ensures stable magnetic coupling, electrical isolation, and protection against electromagnetic interference. With reliable modulation schemes such as FSK, the system supports low error communication even in dynamic environments. The results indicate strong potential for automotive and industrial usage where safety, isolation, and reliability are critical.

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