Magnetic Field Communication for Small Cell Base Station

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***Abstract* – Magnetic Field Communication (MFC) system which consist of an analog board, a FSK modem, and an antenna is designed. Physical layer utilize the FSK modulation method and a center frequency is 132.55 kHz. The system has 2.4kbps transmission rate and communication distance is up to 5m**

***Index Terms* — Magnetic field communication, FSK modulation, Antenna design.**

I. INTRODUCTION

Wireless communication technologies have been used in various service areas as increasing demands of wireless communication technology. As most of these technologies require a wide-band width, a higher transfer speed, and a smaller base station, the technologies using higher frequency area have been studied.

However, the communication method for a natural disasters monitoring, a building state monitoring, a ground state management, a water/soil pollution monitoring, and etc. is demanded in these days. The wireless communication technology under the medium far from air is therefore required [1].

The wireless communication technologies using low frequency magnetic field are researched and developed to communicate under the environment of underground or underwater. That is why the magnetic field has different characteristic from electric field, which has identical transmission characteristic without reference to materials.

The magnetic field communication system which consist of the analog board, the FSK modem, and the antenna is designed in chapter II [2]. A packet structure is also described. The experimental result and conclusion are presented in chapter III and chapter IV respectively.

II. MAGNETIC FIELD COMMUNICATION SYSTEM

A. System Design

The physical layer is implemented using the FSK modem that enables half duplex communication.

Digital data from the network layer is serialized by the digital transmitter and fed as input to the modulator. The modulator divides the local oscillator frequency by a definite factor depending on whether the input data is high level logic or low level logic. It is fed to the gain amplifier to generate FSK modulated signals. The FSK modulated signals fed as input of voltage amplifier and the output of voltage amplifier is used as input of current amplifier. Finally, the signal is transmitted through the Tx antenna.

The incoming FSK signal from the Rx antenna is input to a low noise amplifier and voltage amplifier. The output of voltage amplifier fed as input of high frequency band pass filter. The Mixer block multiplies the filtered FSK signals with a locally generated signal to produce heterodyned frequencies. The intermediate frequency band pass filters further remove out-of-band noise as required for further demodulation. This signal is fed to the correlator which produces a DC component consisting of high and low, and a higher frequency component. The signal is then fed to the low pass filter that outputs only the demodulated digital data at 2.4 kbps and suppresses all other higher frequency components generated in the correlation process. The output of the low pass filter is digitized by the hysteresis comparator. Finally, the digital receiver deserializes this data and outputs to the Network Layer for interpretation.

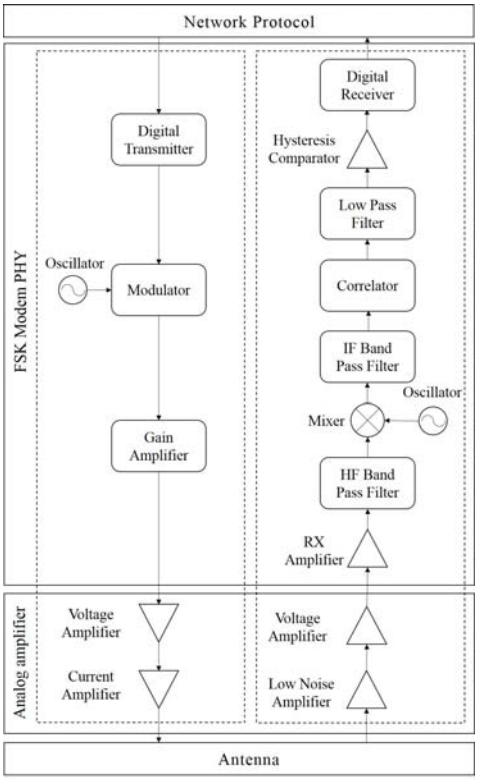

Fig. 1. Magnetic Field Communication System block diagram

B. *Packet Structure*

The magnetic field communication network protocol defines a transceiver packet structure, which is used for data transfer between Tx and Rx antenna.

A transceiver packet is apportioned into a variable length header (minimum 6 bytes to maximum 20 bytes, depending on address type), a variable length payload (minimum 0 bytes to maximum 31 bytes), and a packet CRC byte. This packet (preceded by a one byte preamble "0xAB") is then transmitted by the Modem PHY and the analog amplifier circuit. The format of the transceiver packet is shown in Table I.

TABLE I
TRANSCEIVER PACKET STRUCTURE

Byte offset	Bit Offset							
	7	6	5	4	3	2	1	0
0x00	SA Type	DA Type		Service Type	RSVD		Response	RSVD
0x01	Destination Address (8-bit Logical, 16-bit Extended Logical or 64-bit Physical)							
0x02	Source Address (8-bit Logical, 16-bit Extended Logical or 64-bit Physical)							
0x03	Command							
0x04	RSVD			Payload Length				
0x05	Seq Num				Payload Length			
0x06	Payload (0 to 31 Bytes)							
	Transceiver Packet CRC							

C. *Antenna Design*

The resonant frequency of LC circuit is determined by both inductance and capacitance as equation 1 [3].

$$f = \frac{1}{2\pi\sqrt{LC}} \quad (1)$$

The inductance of antenna is proportional with both number of turns and cross section. In other word, the generated magnitude of magnetic field is determined by these parameters. Then, the capacitance can be calculated by equation 1 with the determined inductance and resonance frequency.

The Quality factor (Q-factor) can be considered by the S11 characteristic of antenna at the resonant frequency. The Q-factor is determined by inductance and resistance as equation 2.

$$Q-factor = \frac{\omega L}{R_0 + R_r} \quad (2)$$

III. EXPERIMENTAL RESULTS

The parameters of magnetic field communication system is shown in Table II.

TABLE II
MAGNETIC FIELD COMMUNICATION SYSTEM PARAMETERS

List	Value
Carrier frequency	131.8kHz (Logic '1') 133.5kHz (Logic '0')
Modulation method	FSK modulation
Communication distance	~5m
Antenna (Tx)	80mm (diameter), 40turns
Antenna (Rx)	80mm (diameter), 40turns
Board size	100mm * 100mm

The experimental setup is shown in Fig. 2. The system board consist of power circuit, modem, Tx circuit, and Rx circuit, and the size of this is 100mm*100mm. The diameter of antenna is 80mm and number of turns is 40, and the Tx antenna and Rx antenna have identical specification.

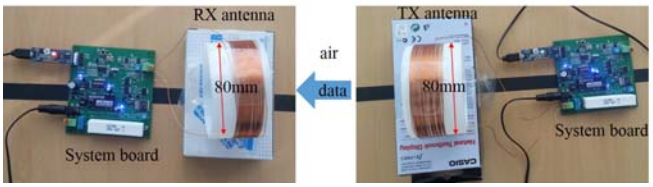

Fig. 2. Experimental setup

The experimental result is shown in Fig. 3. The Tx waveform and Rx waveform are described. The peak voltage of Tx is 150V and the peak voltage of Rx is 0.62V. The experiment is performed at 5m between Tx and Rx antenna.

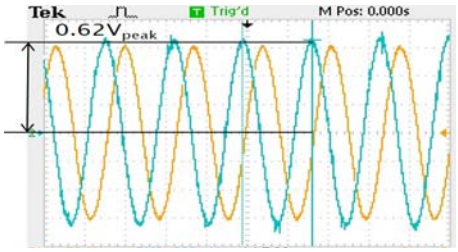

Fig. 3. Tx/Rx waveforms at distance of 2m (Ch1: yellow, Tx, 50V/div, Ch2: blue, Rx, 200mV/div)

IV. CONCLUSION

In this paper, the magnetic field communication system was designed. It consists of analog board, modem, and antenna. The FSK modulation method is utilized and the performance is verified at 5m distance between Rx and Tx antenna.

ACKNOWLEDGMENT

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