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主　論　文　の　要　旨

論文題目　**Development of an FPGA-based MI sensor system for high compatibility and high resolution**
(FPGA を用いた高互換性と高分解能を実現する MI センサーシステムの開発)

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論　文　内　容　の　要　旨

The MI (Magnetic-impedance) sensor system is studied in this paper. The background, such as magnetic signals and applications of the magnetic sensor is introduced in chapter 1. The history and comparison of magnetic sensors are surveyed. Compare with other magnetic sensors, the MI sensors show great potentials for IoT, due to the requirements of the sensors in future applications, there is a need to improve the MI sensor system to suitable the future applications of the Internet of Things (IoT).

The detail and principle of the MI sensor are discussed in chapter 2. In addition to this, the system of the MI sensor and the previous research are discussed, there are some limitations of the conventional MI sensor system based on the sample and hold circuit. Therefore, the purpose of this research is to develop a high-compatibility and high-resolution MI sensor system which can be easily integrated.

The previous research of the author and experimental procedures are introduced in chapter 3. In order to improve the limitation of the conventional MI sensor system, a novel MI sensor system is proposed by combining the conventional system and the author's previous research. The proposed MI sensor system is developed by using an Op-amp integrator circuit. The influence of the conversion time of Analog-to-Digital Converter (ADC) has been investigated. A lower noised level of the system can be obtained by using an appropriate conversion time of ADC.

In order to detect the weak magnetic signal, the MI gradiometer based on the proposed system is designed and discussed in chapter 4. The proposed MI sensor system is a hybrid analog/digital system and developed via Field-Programmable Gate Array (FPGA). Therefore, the development of the proposed sensor system consists of two parts (Program and circuit). It is easier to synchronize the sensor circuit with an FPGA controlled ADC through the program. The magnetic field to output voltage characteristic, weak magnetic field detection, and the noise level of the proposed MI gradiometer has been investigated.

In order to determine the characteristics of the proposed system, a magnetometer is developed and tested in chapter 5. The proposed system is improved to compatible with other smart systems via Transistor-Transistor Logic (TTL)/CMOS interface, and the characteristic of the proposed sensor system has been investigated. The operation of the proposed system can be controlled by the FPGA through the TTL/CMOS interface. Thus, the sensor circuit can be considered as a programmable circuit, in addition to this, the FPGA in the proposed system can be replaced by a CMOS IC circuit or ASIC (application specific integrated circuit). On the other hand, due to the capability of the programmable circuit, the sensitivity of the proposed system is governed by the FPGA, therefore, the common-mode noise can be suppressed by changing the control signal of the analog switch in the Op-amp integrator. The magnetic field to output voltage characteristic, dynamic range, linearity, and the noise level of the proposed MI magnetometer with different program control have been investigated. In order to sample the output of the sensor corresponds to the rising edge and the falling edge of the pulse current, the sensor circuit is more complex than the conventional sensor circuit, especially the proposed MI gradiometer. In order to simplify the sensor circuit of the proposed system, a simplified MI sensor system has been developed in this chapter. Additionally, the output of the MI sensor is analyzed in this chapter, due to the principle of the MI sensor, the pick-up coil in the off-diagonal type MI sensor is like a search coil, thus, the detection of the pick-up coil can be considered as a transient response with an induced voltage, the pick-up coil consists of resistance, inductance, and parasitic capacitance between the coil. Depending on our investigation and calculation, the characteristic of the proposed system is close to our simulation, which is the output of the proposed system is proportional to the number of turns of the pick-up coil.

The conclusion and future works are discussed in chapter 6.

As a result, the proposed sensor system shows high resolution and high compatibility with the different types of MI sensors.