ICP MONITOR

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Abstract

An intracranial pressure (ICP) monitor is used to detect changes in the cerebrospinal fluid pressure caused by shunt malfunction. To address the concern of a finite lifespan an ICP monitor with an inductively powered solenoid was designed in conjunction with in internal capacitive transducer. An LC circuit demonstrated changes in the resonance frequency corresponding to changes in pressure.

Problem Statement

Design a non-invasive means to measure intracranial pressure through an inductively powered device. Transmit power across the scalp to an internal pressure gauge. The signal is interpreted externally as a pressure measurement.

Motivation

Shunt Purpose and Function

- Hydrocephalus incident rate of 1%

Shunt Malfunction

- 50% failure in 2-3 years
- Invasive and non-invasive diagnosis

Design Constraints

Transducer

- MRI compatible
- -3 – 30 mmHg
- Biocompatibility
- Lifespan 20 years

Power Supply

- 1.5 cm gap
- 5 Volts
- Current < 100 mA
- Completely external

ICP Monitor Design

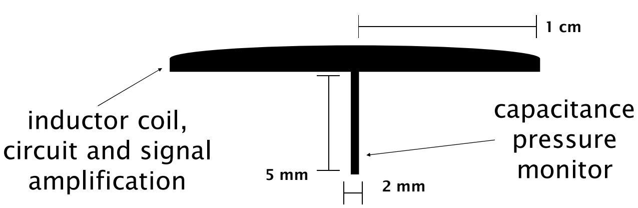

Figure 1. ICP monitor design.

Circuit Design

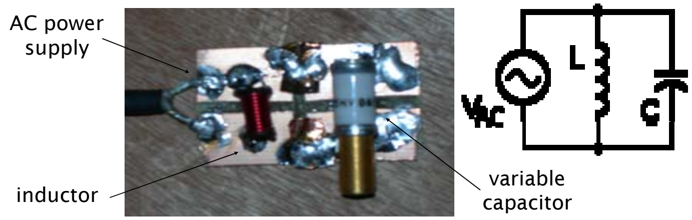

Figure 2. LC circuit design.

Frequency Testing

$$Z_{eq} = (j\omega C - \frac{j}{\omega L})^{-1}$$

Figure 3. Capacitance testing data.

Changes in the capacitance of the LC circuit alters the resonance frequency which can be interpreted externally as a change in intracranial pressure.

Capacitor Designs

$$C = \frac{\epsilon_0 A}{d}$$

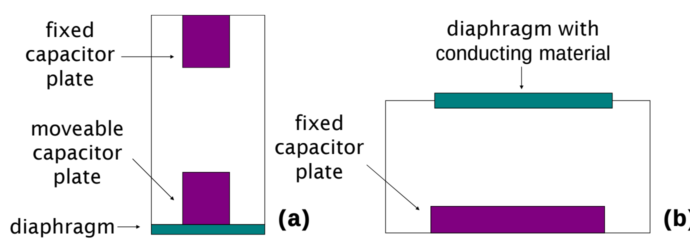

Figure 4. (a) Diaphragm with attached capacitor. (b) Conducting diaphragm with fixed plate.

A change in intracranial pressure will change the distance between capacitor plates changing the value of the capacitance

Solenoid Specifications

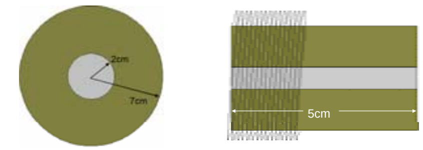

Figure 5. Solenoid Dimensions

Driving the solenoid with n = 5000 turns/meter at 60 Hz, 850 mA, and 12 VAC produces a changing magnetic field to induce a minimum of 3.5 Volts.

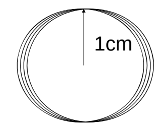

Figure 6. Internal Coil

A voltage is induced in the secondary coil with N = 10 turns and 1cm radius according to Faraday's Law

EMF Testing

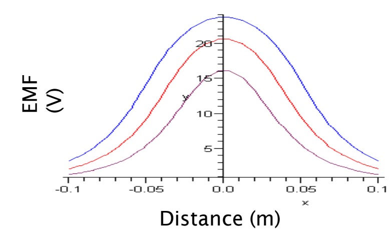

Figure 7. EMF induced in secondary coil versus distance

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Future Work

- Complete circuit configuration
- FM circuit transmission
- Place circuit components on PIC microcontroller
- Miniaturization