Wireless monitoring of implantable pressure sensors

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Introduction

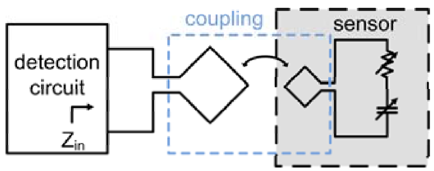
The ability to observe time evolution of *in vivo* biopotential, biochemical, and biomechanical properties has the potential to yield breakthroughs in our understanding of human health and disease. Such enabling technology for continuous concurrent *in vivo* monitoring is sure to become the standard of care as an indispensible clinical tool in the early detection and treatment of disease. We are addressing the need for a generic system of chronically implantable sensors and a common detection platform to individually address and monitor them wirelessly.

GHz operation frequencies are used to reduce both implant and interrogation system dimensions. Degradation of path loss through tissue at higher frequencies is compensated by higher achievable antenna gain and sensor radar cross sections for fixed size constraints.

Methods

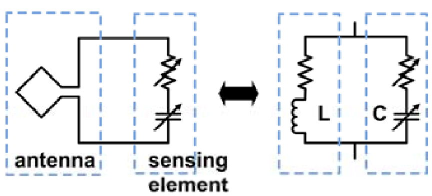
Resonant excitation and backscatter sensing techniques are utilized to circumvent the need for battery power or active energy harvesting thereby limiting the size and complexity of the disposable implant device.

$$\begin{bmatrix} V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix}$$



$$Z_{in} = Z_{11} - \frac{Z_{12}Z_{21}}{Z_{22} + Z_L} \qquad S_{11} = \frac{Z_{in} - Z_0}{Z_{in} + Z_0}$$

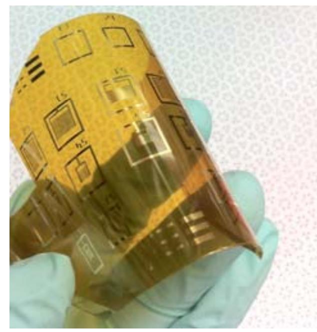
The current device design features a capacitive sensing element integrated with an inductive antenna to create a resonant structure whose resonant frequency decreases with increasing applied pressure.



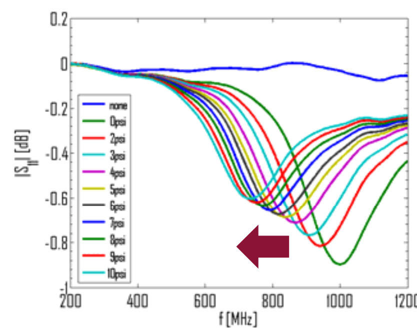
$$f_0 \sim \frac{1}{2\pi\sqrt{LC}}$$

Results

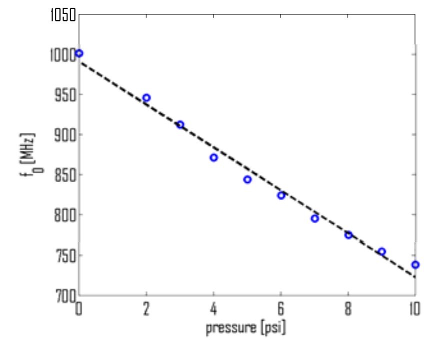
Wireless pressure monitoring devices (1cm×1cm) are fabricated on a thin flexible polyamide substrate to allow for ease of delivery and chronic implantation.



Resonant peak shifts in the input impedance spectrum (S_{11}) of the external 1cm diameter pick up coil are measured with varying applied pressures. No resonant peak is detected in the absence of a sensor device.



The measured pressure calibration curve demonstrates linear detection with no hysteresis.



Conclusions

These flexible wireless pressure monitoring devices can be chronically implanted subcutaneously to study peripheral blood pressures during the progression and treatment of cardiovascular diseases such as hypertension and atherosclerosis. They can also be used to assess intradiscal and intraosseous pressures in biomechanic studies and treatment of orthopedic and spinal disorders. Other applications include pressure monitoring in cerebral, myocardial, bowel and limb ischemia / reperfusion.