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Wireless Implantable Blood Pressure Sensing Microsystem Design for Monitoring of Small Laboratory Animals

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A design of a novel wireless implantable blood pressure sensing microsystem for advanced biological research is presented. The system employs a miniature instrumented elastic cuff, wrapped around a blood vessel, for small laboratory animal real-time blood pressure monitoring. The elastic cuff is made of biocompatible soft silicone material by a molding process and is filled by insulating silicone oil with an immersed MEMS capacitive pressure sensor interfaced with low-power integrated electronic system. This technique avoids vessel penetration and substantially minimizes vessel restriction due to the soft cuff elasticity, and is thus attractive for long-term implant. The MEMS pressure sensor detects the coupled blood pressure waveform caused by the vessel expansion and contraction, followed by amplification, 11-bit digitization, and wireless FSK data transmission to an external receiver. The integrated electronics are designed with capability of receiving RF power from an external power source and converting the RF signal to a stable 2 V DC supply in an adaptive manner to power the overall implant system, thus enabling the realization of stand-alone batteryless implant microsystem. The electronics are fabricated in a 1.5 μm CMOS process and occupy an area of 2 mm × 2 mm. The prototype monitoring cuff is wrapped around the right carotid artery of a laboratory rat to measure real-time blood pressure waveform. The measured *in vivo* blood waveform is compared with a reference waveform recorded simultaneously using a commercial catheter-tip transducer inserted into the left carotid artery. The two measured waveforms are closely matched with a constant scaling factor. The ASIC is interfaced with a 5-mm-diameter RF powering coil with four miniature surface-mounted components (one inductor and three capacitors) over a thin flexible substrate by bond wires, followed by silicone coating and packaging with the prototype blood pressure monitoring cuff. The overall system achieves a measured average sensitivity of 7 LSB/mmHg, a nonlinearity less than 2.5% of full scale, and a hysteresis less than 1% of full scale. From noise characterization, a blood vessel pressure change sensing resolution of 1 mmHg can be expected. The system weighs 330 mg, representing an order of magnitude mass reduction compared with state-of-the-art commercial technology.

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