Development of a Telemetry Unit for Wireless Monitoring of Bone Strain

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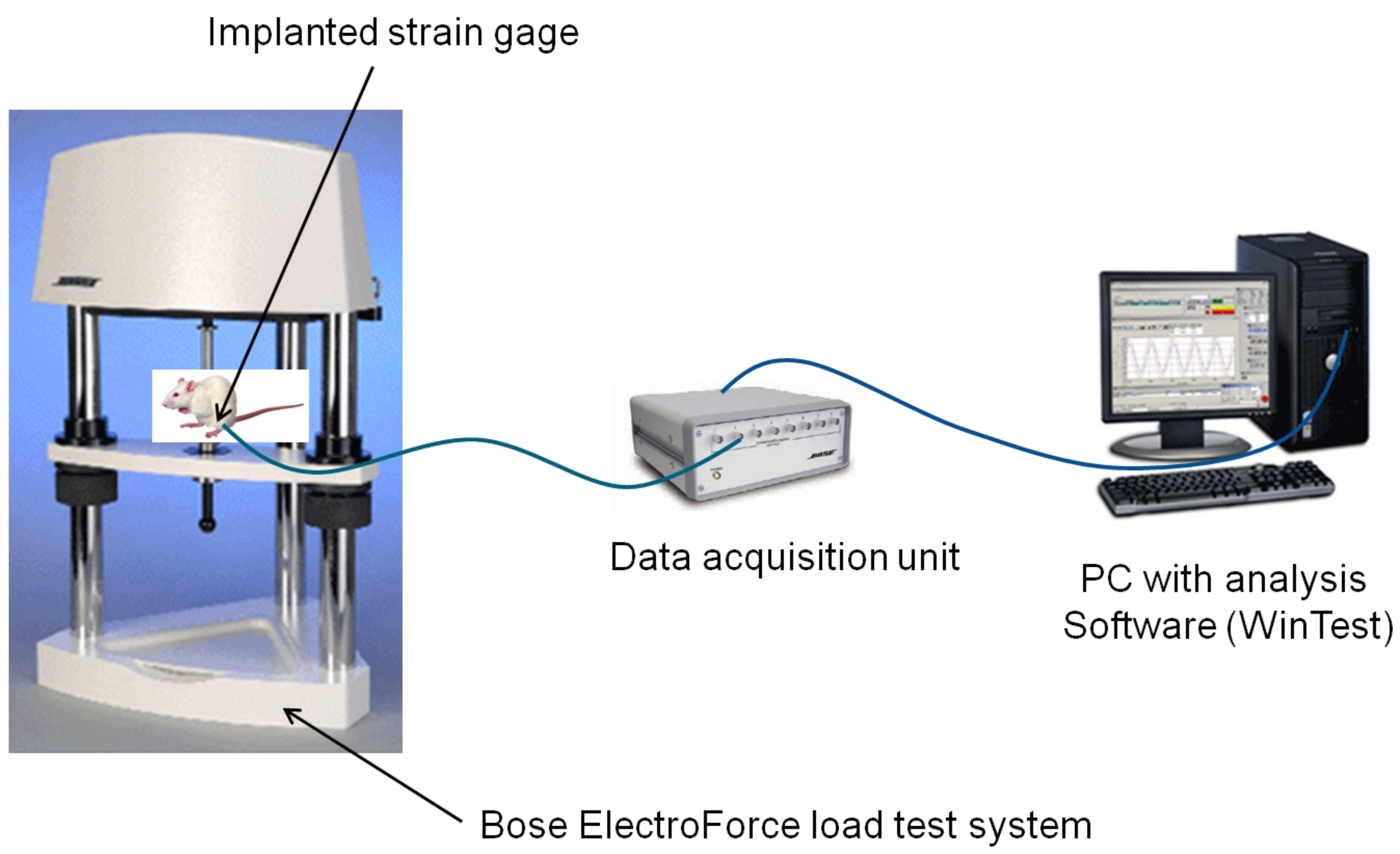
Abstract: A telemetry unit designed to monitor strain in bones is presented. This unit allows studying the relationship between bone load and bone mass in scenarios that were not possible with current setup. The current measuring setup employs a bench top load instrument and a data acquisition unit to read the output of strain gage sensors attached to the ulna of a mouse. Although precise, this setup is bulky and requires complete immobilization of the mouse. The telemetry unit developed by the authors replaces the data acquisition unit in the current setup and is able to wirelessly transmit the readings of the strain gage to a remote computer. The telemetry unit makes possible the collection of bone strain data in scenarios where the mouse is free to move or while performing fatigue-inducing exercises.

The unit has been designed around an ultra low-power microcontroller (MSP430). The microcontroller makes the design highly flexible and programmable. The telemetry unit also includes a high-performance instrumentation amplifier to amplify the strain gage output. The gain and offset of the amplifier are digitally set by the microcontroller eliminating the use of manual potentiometers. The board has an expansion connector that allows up to 16 additional strain gages to be connected to the unit and incorporates a low-power radio transceiver operating in the 2.4 GHz ISM band. The data transmitted by the unit is received by a base station connected to a computer via a USB cable. The telemetry unit has been tested in a lab setting and is able to transmit the strain data at distances greater than 20 m while consuming less than 30 mW of power. This low power consumption allows the unit to be powered by a micro-battery weighting less than 3 grams. The telemetry unit can be used in other biomedical applications such as in the monitoring of orthopedic implants and can be easily configured to use other type of sensors.

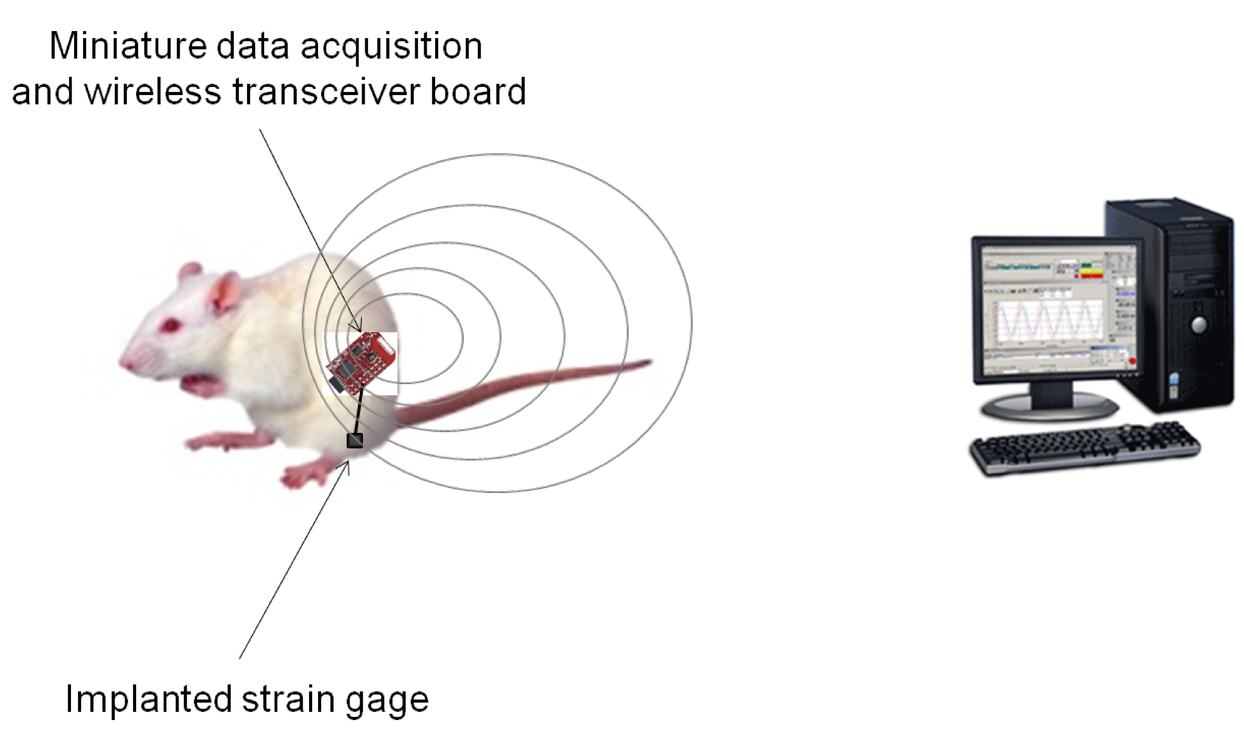
Motivation

The motivation for this work came from the need to measure bone strain in mice. In the current setup, the mouse has to be immobilized while a known load is applied to its bones. A wireless solution would allow to study bone strain under more realistic conditions while the mouse is moving around.

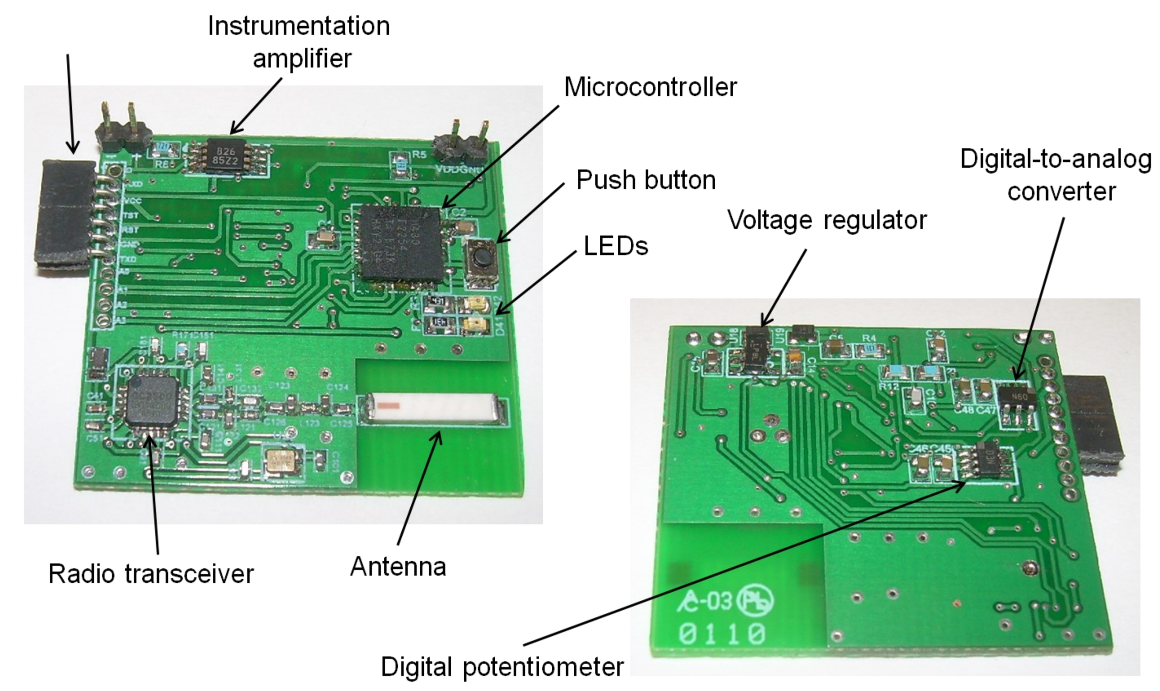
Current Setup

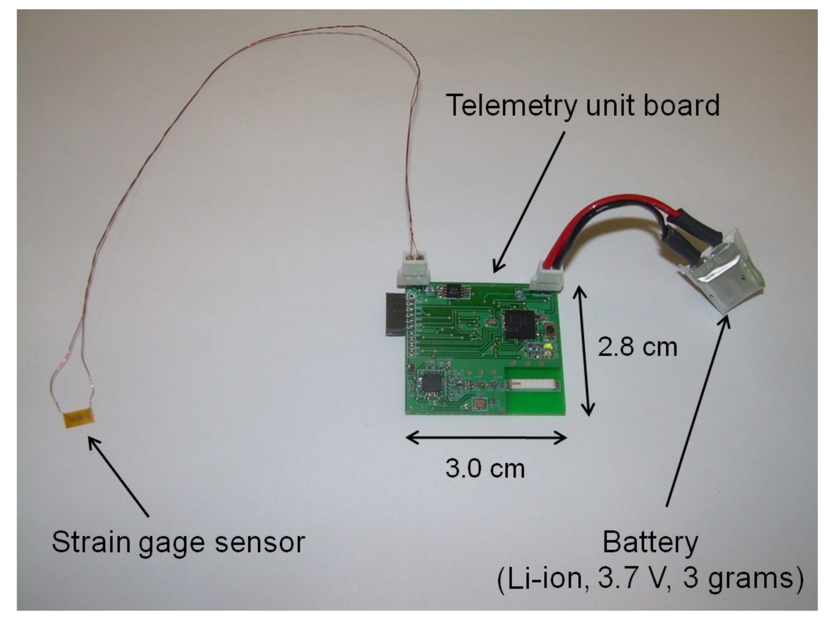


Proposed Solution

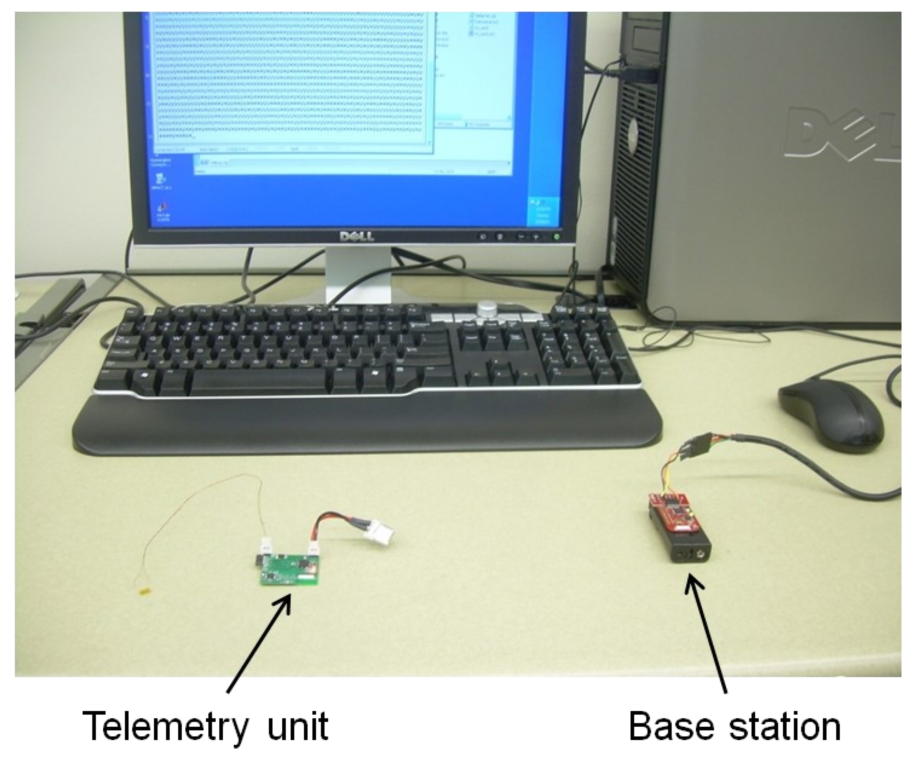


Telemetry Unit Board

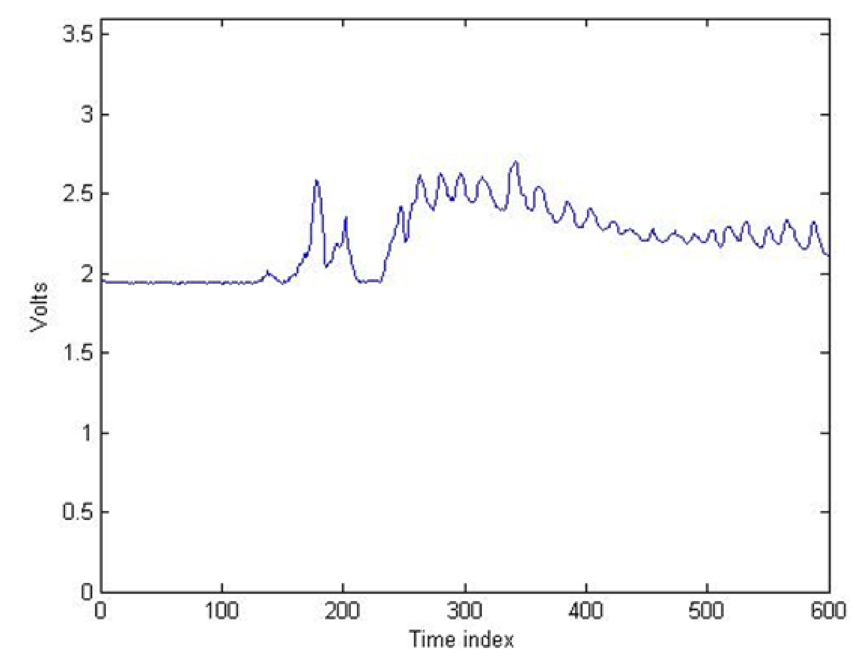




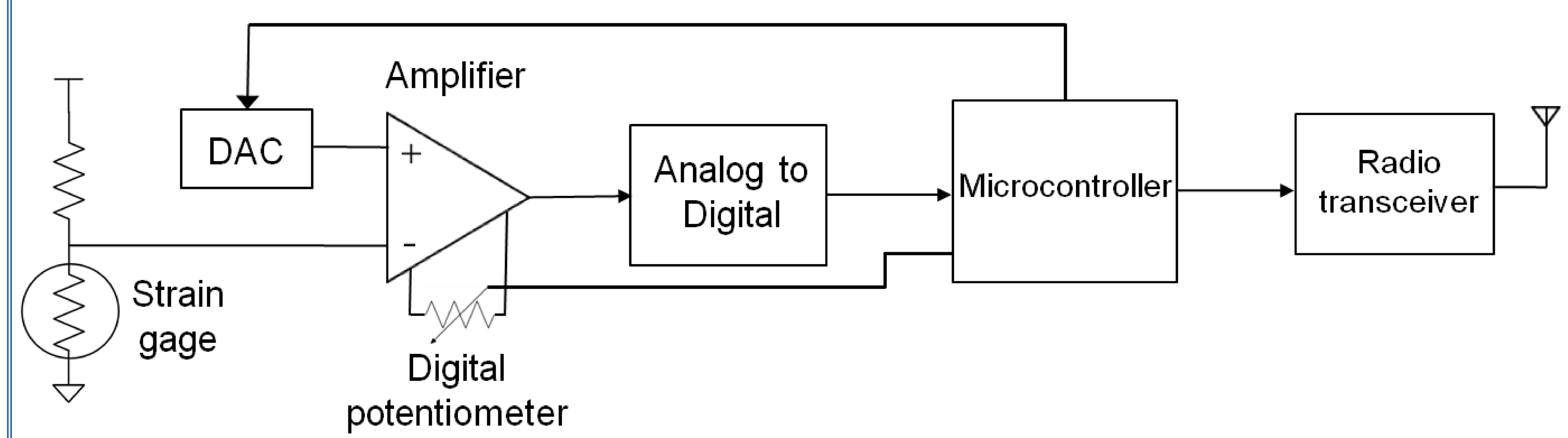
Computer Interface



Acquired Data



Circuit Design



Conclusions and Future Work

A wireless sensor to monitor strain has been presented. The sensor replaces a large data acquisition box in the current setup. The sensor includes an ultra low-power microcontroller that coordinates the sensor sampling and the radio transmissions. The microncontroller can also change the gain of the amplifier and auto calibrates the amplifier. We are currently working on the second version of the sensor which will have the same functionality but with a smaller size. To that end we will employ the CC2510 system-on-a-chip from Texas Instruments. This device combines a microcontroller and a radio unit in the same chip. The balun network currently used to connect the antenna to the transceiver will be replaced by a integrated balun from Anaren. These changes will allow us to have a sensor board of 1.5 cm x 1.5 cm.

ACKNOWLEDGMENTS
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