

PhysioLinQ: Remote measurement in socially housed animals

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Abstract

PhysioLinQ has been developed by Telemetry Biometry as a device to measure heart rate, body temperature and activity in socially housed small animals.

Our product differs from other commercially available telemetry systems in some very important aspects

Signal transmission is not continuous, but intermittent: Collected physiological data are pre-processed within the implant and are sent at pre-defined time intervals. Since every transmitter can be uniquely addressed by an identification code, a number (up to 20) of implants may be active at the same location. This means that, contrary to other telemetry systems, PhysioLinQ can monitor social interaction between animals.

As PhysioLinQ uses inductive powering instead of batteries, it can be used for long duration experiments. Moreover, not using batteries makes a significant reduction of the volume of this telemetry system possible.

Promising results have been achieved with prototypes. PhysioLinQ will be introduced commercially at the end of 2006.

Keywords

Telemetry, socially housed animals, physiological body parameters, intermittent measurement, remote measurement.

1 Introduction

Major themes in designing biotelemetry implants are saving energy, reduction of volume and gaining biologically realistic data.

An implant that uses energy economically will be attractive for two very straightforward reasons: A given amount of energy can be used for gathering more data and there will be less stress for animal because replacing the energy source can be done less frequently. Most of the implants currently used have batteries as their source of energy. These batteries have to be replaced every 2-6 months.

Miniaturization of the implants is important because smaller implants open possibilities in a wider range of animals. Many commonly used implants can be used for rats and bigger animals, but turn out to be relatively big for use within mice.

From a biological point of view, the optimal environment for measuring behavior of animals

would, of course, be their natural environment. Given the limitations of a laboratory setting, ways should be explored to find a realistic approximation. As, for instance, mice and rats are very social animals, the fact that many current biotelemetry systems can only monitor individual housed animals, seems to be a very severe limitation.

In developing PhysioLinQ we tried to find an optimal design that does justice to these themes.

2 PhysioLinQ Design

PhysioLinQ measures heart rate, body temperature and activity in socially housed animals. These are among the most frequently measured variables in animal research. Figure 1 shows a typical setup of the PhysioLinQ system.

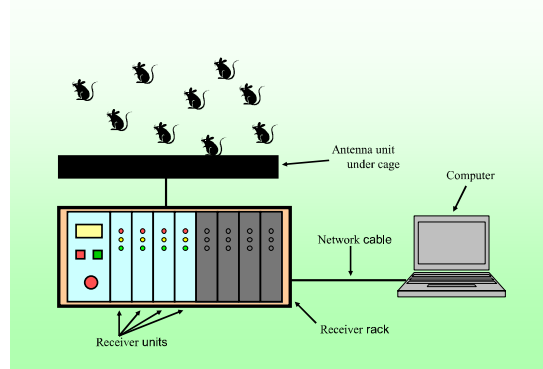


Figure 1. Setup of a PhysioLinQ system.

Several animals (mice, rats) in which PhysioLinQ is implanted, are housed together in a cage. This cage is placed on a 45x45 cm antenna unit that contains both an inductive powering system and a receiving antenna. The inductive field, generated by the powering system, serves as the energy source for the implants. The antenna unit is connected to a receiver rack. One or more receiver racks are connected to a (personal) computer via a TCP/IP network connection. This configuration makes it possible to place the receiver racks at the animal's location and the computer at a remote location.

Software, specifically designed for the PhysioLinQ system, stores the data. Data can be exported in CSV and native EXCEL format for further processing with commercially available software packages. As the software is designed to support TCP/IP, data can easily be made available via internet. This makes remote monitoring possible.

Each receiver rack can hold up to four receiver units. One or more receiver units can be connected to an antenna unit to facilitate synchronous measurements on a number of animals. Via a (TCP/IP) network, several receiver racks (up to five) can simultaneously be accessed. An example of a network setup is shown in Figure 2.

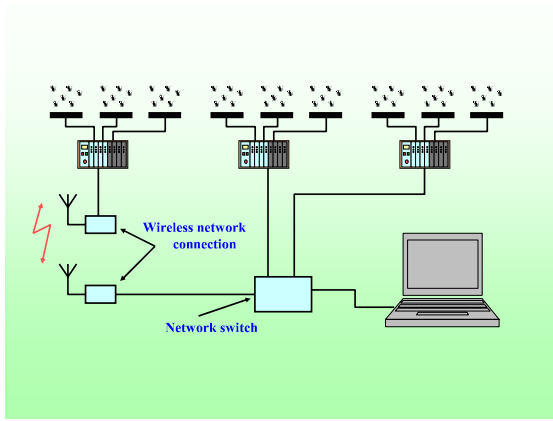


Figure 2. Possible PhysioLinQ network configuration.

Via the induction field, an identification code is intermittently sent to a specific implant. Upon decoding this call, the implant responds by sending its implant data. Each implant has a unique, 24 bit identification code. Implants can be called in any desired sequence. The period over which data will be measured and subsequently sent to the receiver, can be set in the software.

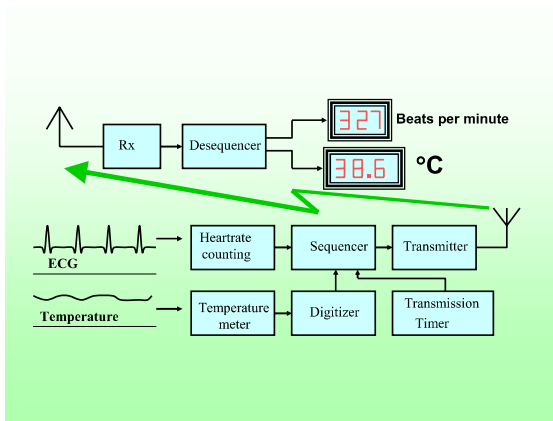


Figure 3. Schematic representation of the intermittent transmission principle

The intermittent character of the data transmission makes it possible to monitor more than one animal simultaneously with one receiver. Measurement data from one animal will be followed by data from a second animal and so on. Many implants can be monitored in the same available radio channel.

In addition to this simultaneous monitoring, it is also possible to make a set-up for synchronous measurement of instrumented animals. In this configuration each animal will be connected to one receiver unit. As the identification code for different animals can now be sent at exactly the same time, measurements over exactly the same period are possible.

2.1 Temperature

The temperature sensor circuit uses a resistive temperature sensing element (thermistor). Two reference resistors are added to the circuit with values that represent the lower and upper end of the temperature range to be measured. Because the

values of these reference resistors are exactly known and all three values (of sensor and two resistors) are sent to the receiver system, a very accurate temperature measurement is possible. Absolute accuracy is ± 0.1 °C and resolution is ± 0.02 °C.

2.2 Heart Rate

The heart rate circuit gets its signal from two ECG electrodes that are placed along the electrical axis of the animal's heart (see Figure 4).

The ECG signal is picked up, amplified and filtered by a programmable band pass filter. The band pass filter suppresses all other signals such as muscle artifacts. Programmability is necessary because a QRS complex of ECG signals from different animal species differ considerably in width. So for each category of QRS complex the right frequency of the band pass filter is programmed.

The heart rate counter accumulates the received QRS complexes from the animal's heart. After a known time interval, the value is transmitted to the receiver and the counter is reset to zero. The counter value represents the average heart rate over the time interval in between two transmissions.

2.3 Activity

Animal activity is measured by using a piëzo electrical accelerometer. Output of the activity circuit is calculated as the number of times the acceleration signal amplitude exceeds a preset threshold level.

A small threshold level means that small movements of the animal will already generate sufficient activity counter values. A high threshold level means that only fast accelerations will be recorded. When it is expected that animals will be highly active, a prescaler can be switched on to reduce the activity movement counts.

The content of this counter is transmitted to the receiver system after a known time interval.

2.4 Dimensions

Figure 4 shows the PhysioLinQ implant in its current form.



Figure 4. The PhysioLinQ implant.

The final version of a PhysioLinQ implant will have a volume of 1.0 ml and a weight of 1.5 gr.

3 Results and Discussion

At present, PhysioLinQ prototypes are being tested. Prior versions have been used for more than 12 years. In fact, they are still in use at the Rijksinstituut voor Volksgezondheid en Milieu (RIVM) in Bilthoven, The Netherlands. A prototype

of PhysioLinQ was successfully tested in February 2005 by the European Space Agency (ESA). PhysioLinQ will be incorporated in the Phenotyper, designed by Noldus Information Technology. Moreover, long-term duration studies are being set up. We expect to introduce PhysioLinQ in the fourth quarter of 2006.

Compared to other telemetry systems, PhysioLinQ has some clear advantages. The fact that no batteries are used means that the refurbishing problem does not exist. The inductive powering can in principle provide the implant with energy for many years.

Moreover, being battery-less, volume and weight of PhysioLinQ can be greatly reduced compared to other telemetric implants. A volume of 1.0 ml and a weight of 1.5 gram mean that PhysioLinQ not only can be used in rats, but also in animals, like mice, that are smaller and more sensitive.

Most important, however, is that PhysioLinQ makes it possible to monitor socially grouped animals. The intermittent character of data transmission means that many implants can be monitored, also if only one radio channel is available. Comparable telemetry systems that make use of continuous transmission are severely limited in this respect, since if only one radio channel is available, only one implant can be monitored at the same location. This makes social behaviour studies almost impossible.

In developing PhysioLinQ, we tried to find an optimal design. PhysioLinQ is unique in combining a very economic use of energy, miniaturization and the possibility to monitor socially housed animals.

The development of PhysioLinQ has greatly benefited from the kind cooperation of both Noldus Information Technology and the European Space Agency (ESA).