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VECTRONIC Aerospace

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innovative technology for science and research

Ruminal Heart Rate Data Logger

Table of Contents

1 Pansen Repeater Help Index

2 Introduction

2.1 System Overview

Introduction:

System Components:

The pansen repeater logging system is designed for autonomous measurements of the body core temperature and the heart beat of ruminants over an extended time period. The pansen repeater system contains of the following eight parts:

- Implant logger
- Repeater collar
- Base Station
- USB connection cable
- LED Check Operation device
- Magnet
- Graphical User Interface (GUI)
- Data statistic evaluation programm

Implant logger:

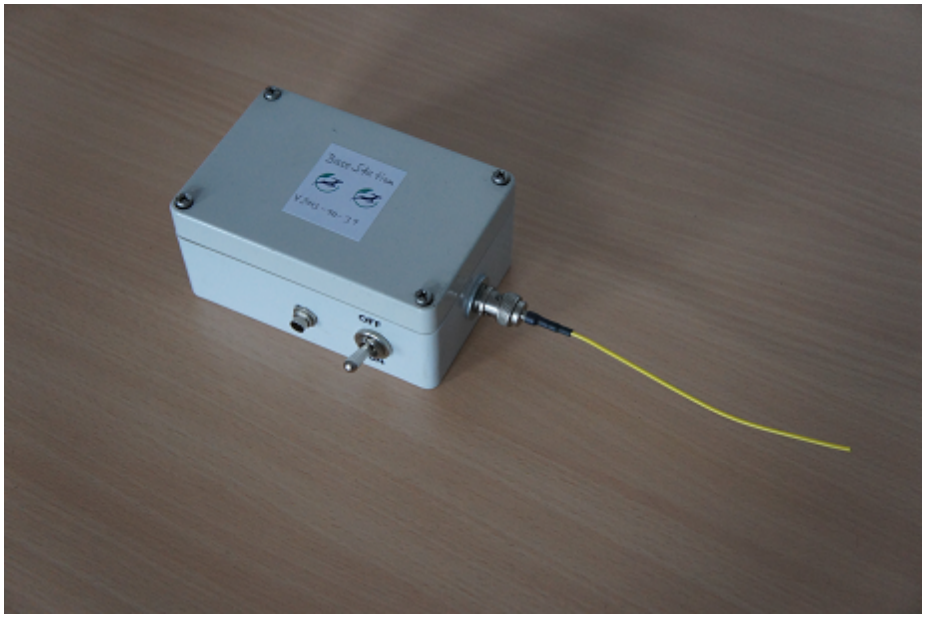
The Implant logger or simply implant is meant to be located in the rumina of the animal of interrest. It measures the animals core temperature in predefined intervalls and sends it wirelessly to the Repeater collar. Additionally the resting heart rate is measured permanently via an acceleration sensor and is also reported in predefined intervalls to the Repeater collar (see Implant timing). The implants operation is started/stopped via a magnet by holding the magnet 2-4 seconds to the marked position on the ceramic head.

Repeater collar:

The Repeater collar or simply repeater is meant to be located at the neck of the animal of interrest. It measures the ambient temperature, the activity of the animal via an acceleration sensor and the position of the head. Data transmitted from the implant is collected by the repeater and saved along with its measured values into an on board memory. The wireless communication is done in the 433MHz ISM band. The saved data can be read out via the USB connection cable and a corresponding GUI which is also used for setting up the configuration options of the repeater. A data gathering and interfacing with the repeater is also possible wirelessly via a Base Station. The repeater also offers the usage of a HF transmitter with several choosable options for easier location of the repeater in the field. (see Repeater timing)

Base Station:

The Base Station or simbly base is aimed for wireless interfacing to a repeater for the purpose of checking of proper operation and data download (see Interfacing overview). A scan for repeaters within communication range can be performed, listing all available repeaters. A monitoring mode for receiving packets of all implants within communication range is also added to be able to verify the operation of the implants and for calibration of the temperature measurement (see Base Station details).



USB connection cable:

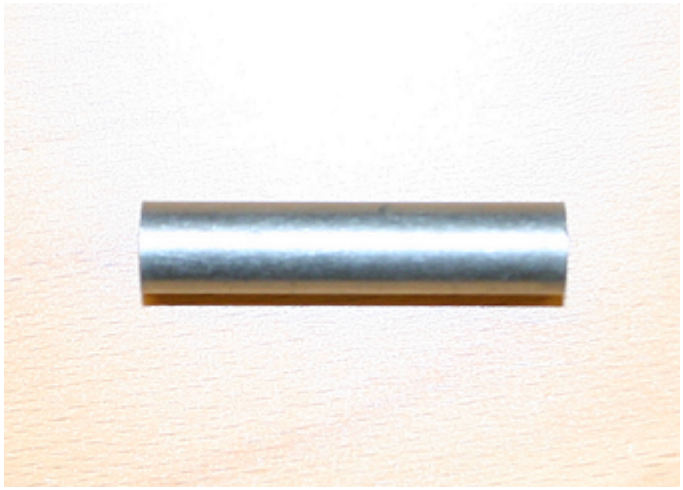
The USB connection cable is used to connect the repeater or the base station to a PC via USB. The cable incorporates a serial interface emulator to enable the PC to communicatie over a COM port with the connected device. On plugging the USB cable into a USB port on the PC an automatic installation of the serial COM drivers is performed. The other end of the cable has a custom connector with a mechanic polarity protection that can be connected either to a repeater or a base station (see Interfacing overview).

LED Check Operation device:

The LED Check Operation device is used in the field to have a means of quick checking the operation of the repeater and indirectly the wireless connection to the implant before freeing the animal after successful installation of the system. For this purpose the device is connected to the repeater via the connector used for interfacing with the PC (see Interfacing overview). The LED blink timing indicates the status of the repeater (see LED Check Operation device behavior).

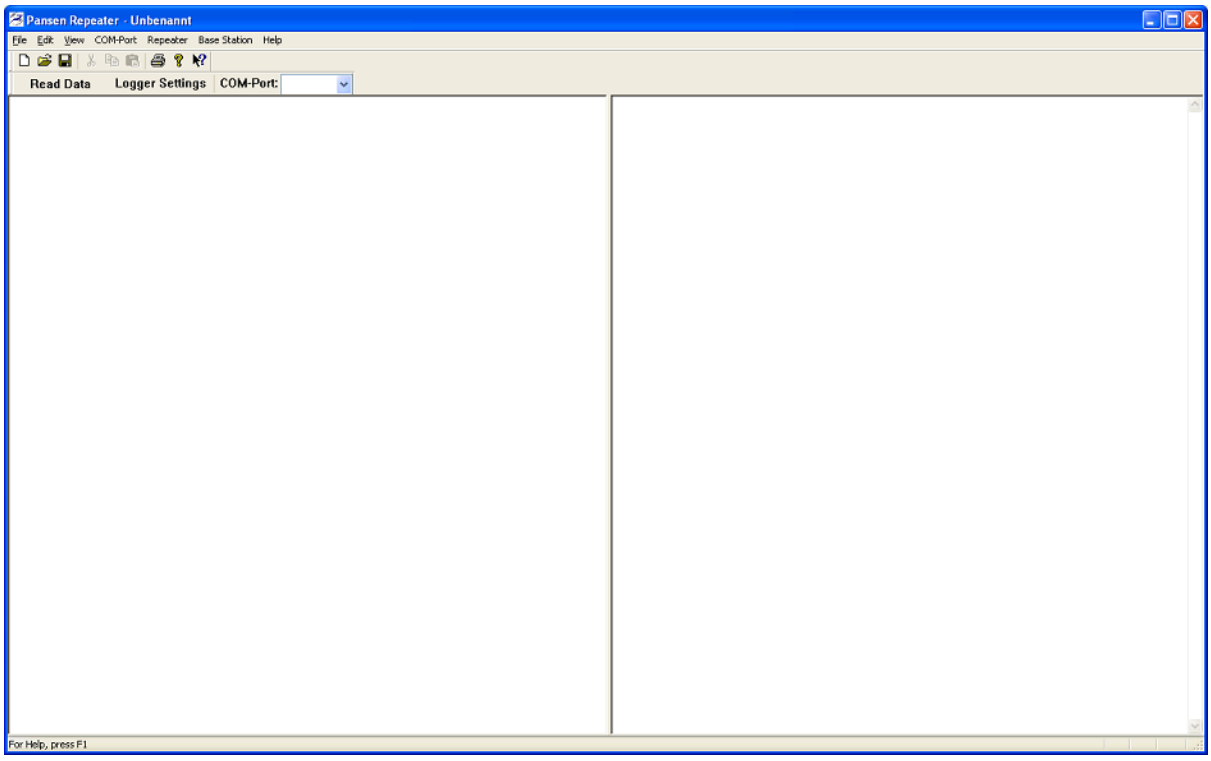
Magnet:

A magnet is used for turning on and off the implant or the repeater if a PC access is not suitable e.g. in the field to avoid extra baggage (e.g. LapTop). To turn the repeater on or off you have to hold the magnet to the respective marking on the devices chassis for two the four seconds.



Graphical User Interface (GUI):

The GUI is the application running on your computer which is used as the interface for users to connect directly to a repeater or a base station.



Data statistic evaluation programm:

At the end of a logging session the gathered data is read out via the GUI and must be post processed by a statistics programm which is available online at the FIWI. For this pupose the data must be uploaded to the server and the evaluation programm will perform a statistical reduction of

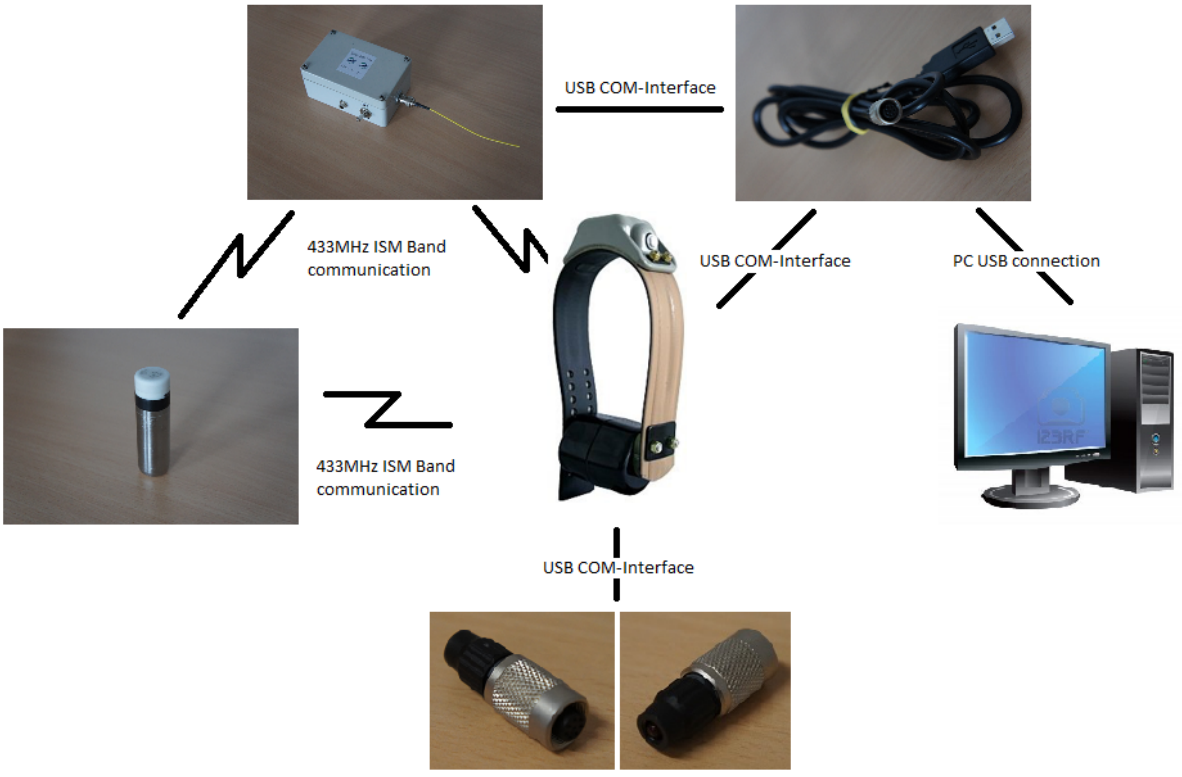
the data leaving only valid data that can be downloaded as a .csv file.

Theory of operation:

Interfacing overview:

Data obtained by the system is saved to memory located on the repeater which can be read out via the GUI over a cable connection or wirelessly via the base station.

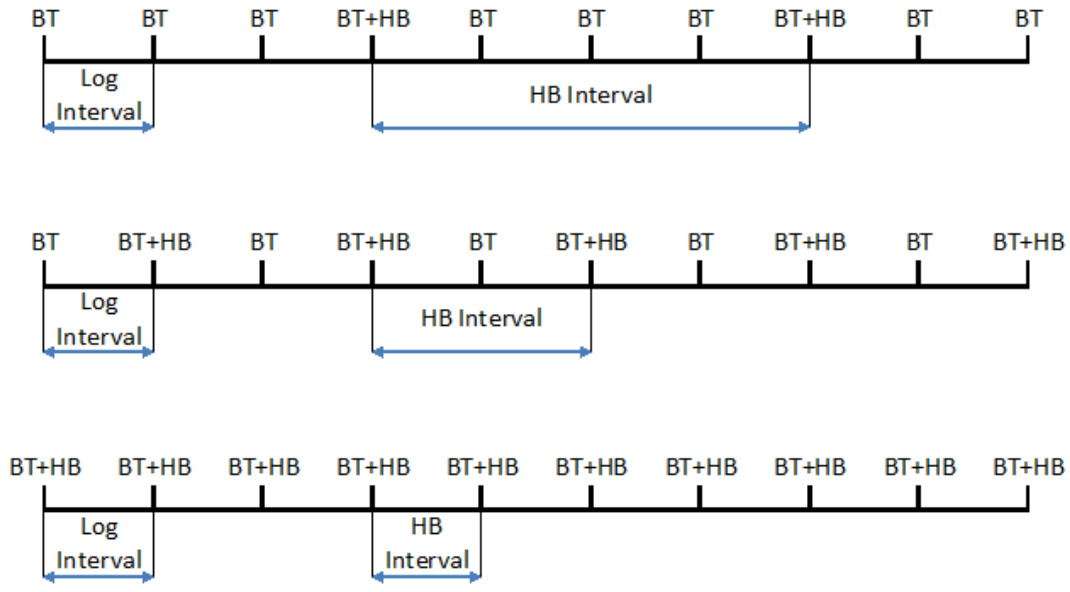
The following figure gives an overview of how the components are interfacing with each other. The implant which has to be located in the animals rumina retrieves body temperature and heart beat data and sends it via the wireless 433MHz ISM link to the repeater collar located at the neck of the animal. The repeater saves this data along with the ambient temperature, the animals activity, the head position value and the RTC (Real Time Clock) to the on board memory. This data can be read out via PC and the GUI if connected directly via the USB connection cable to the repeater. While connected in this way the repeater settings can also be retrieved and changed and the saved packets can be visualized at runtime to check proper operation.



Synchronization:

Implant timing of data packets:

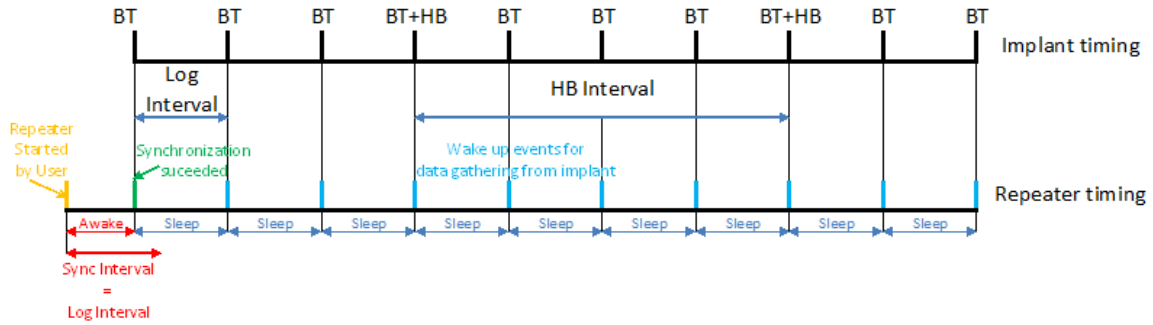
The implant has an unique ID which is also part of every data packet transmitted. This ID is used to avoid the repeater logging data from implants with different implant IDs, for this purpose the implant ID the repeater should log to can be selected via the Logger Settings Dialog. To save battery power and thereby prolonging the systems run time, data transmission is only done in predefined intervalls so called Log Intervals. These intervalls are dictated by the implant in use and can not be changed after purchasing. Therefore the logging intervall as shown in figure below which can be choosen in multiples of 15 seconds should be determined before ordering implant hardware. The body temperature is sent via a dedicated BT packet to the repeater during every intervall, measurement of the heart beat can be performed in every intervall and sent in separate HB packets to the repeater as shown in the third timing example of figure below. But you can also choose to skip the heart beat measurement for a selectable number of intervalls, this gives a HB interval in multiples of the Log Interval as shown in the first two timing examples in figure below. On purchasing of an implant the implant ID, Log interval and HB interval can be selected by the user and set accordingly by the manufacturer, keep in mind that these settings can not be changed by the user anymore.



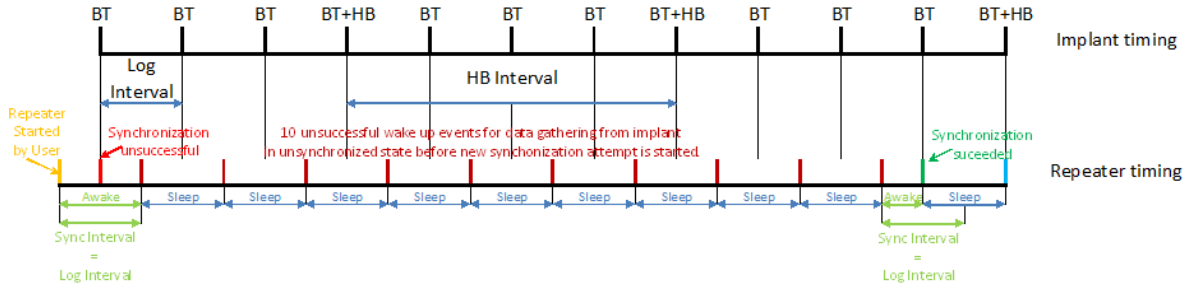
Repeater synchronization:

The operation of the base station is basically to be in a low power state most of the time, in below figures referred to as sleep, and just wake up for a few 100ms to receive the data packets transmitted by the implant. After reception of the last data packet of an interval the repeater searches for a base station in communication range to offer a means of reading out status information and download data remotely via a base station. To achieve propper operation the implant and the repeater must be synchronized in time that the repeater is awake when packets are actually transmitted by the implant and in the mean time save battery life by switching into a low power mode. To synchronize the repeater to the implant which is always sending its packets in the same time interval the repeater checks the ISM frequency on which the implant is sending its data for

packets with the implant ID which the repeater is configured to synchronize to. This listening mode is maintained for the duration of one Sync Interval which equals one Log Interval if no packet with the set implant ID is received at all, and it is started at every start of a repeater logging session. It is recommended to start the implant first and afterwards the repeater to achieve a synchronization with the first synchronization cycle. Below figure shows the timing diagram after a turn on logging event of a repeater and how the repeater synchronizes with the implant. The start of a logging session of the repeater can be initiated via the GUI or by using the magnet turn on/off routine.



If the synchronization at startup is not successful as shown in figure below the repeater goes into sleep mode after one Sync Interval. The next ten Log Intervals the repeater tries to receive data from the implant but since they are not in timely synchronization the repeater will not receive any packet at all. After these ten intervals an additional synchronization intervall is started where the repeater can establish synchronization again which succeeds in figure below. If this synchronization would not succeed during this additional sync interval the repeater would go to sleep and start from the beginning with ten Log Intervals with no packets at all followed by another synchronization interval a.s.o. If for some reason an already synchronized repeater does not receive any packets from the implant in ten consecutive Log Intervals the synchronization would also be started and would behave like at the beginning of a repeater logging session.



The data received from the implant is saved to an on board memory and can be read out via the supplied USB cable (see USB connection cable). Apart of the received data the repeater is also measuring the ambient temperature, the activity of the animal, a head position value and is saving all data every logging intervall along with the on board RTC (Real Time Clock) to the on board memory. To be able to find the repeater more easily a HF transmitter is used which on/off times can be set via the GUI. It offers the user a selection to set daily transmit times, monthly transmit days and

yearly transmit months that are user configurable and for the purpose of saving battery live (see VHF Settings).

Base Station details:

The task of the base station is basically to offer the user the opportunity to read out the current status of the repeater or download the logged data remotely i.e. about 100m maximum free field communication distance. Since the repeater is not accessible via the ISM link most of the time because it is in a low power mode to save battery life as discussed in Repeater synchronization, the base station is not able to initiate a communication to the repeater by itself. Therfore rather the repeater is implemented to initiate the communication to the base station by sending out a base station request at the end of every wake up after retreiving data from the implant has ended. Due to this strategy it is not possible to read out the repeater settings via the base station immediately upon request i.e. clicking the read button and getting the data response immediately. A click of the read button rather sends the base station into a listen mode where it waits for the base station to send a connection request packet which can take up to one Log Interval. The request packet contains the implant ID to be able to distiguish requests from different repeaters. The user has the possibility to pick the implant ID of the animal where data should be retrieved from via the GUI (see Implant ID Picker). This request is acknowledged when the connection request packet has the user selected implant ID. In this case communication is established and data can be retreived. If no packet with corresponding implant ID is received the base station stays in receive mode indefinitely, this can be the case if the repeater is out of range and no communication is possible. To check which repeaters are in connection range the user can listen to all repeaters irrespective of the implant ID and display them on the screen (see Loggers in vicinity group).

LED Check Operation device behavior:

This device is meant to have an easy and quick way of verifying whether the repeater is started correctly and whether it is synchronized with the implant. For this purpose you have to connect the LED Checker to the repeater via the communication interface connector. If the repeater logging is not started jet the led will be off. After enabling the repeater logging either via magnet or GUI the LED will blink every 2 seconds. When the repeater succeeds in synchronizing with the implant the LED will blink every 1 second.

3 Menus

3.1 File menu commands

File menu commands

The **File** menu offers the following commands:

New	Creates a new document.
Open	Opens an existing document.

Close	Closes an opened document.
Save	Saves an opened document using the same file name.
Save As	Saves an opened document to a specified file name.
Print	Prints a document.
Print Preview	Displays the document on the screen as it would appear printed.
Print Setup	Selects a printer and printer connection.
Exit	Exits Pansen Repeater.

3.2 Edit menu commands

Edit menu commands

The **Edit** menu offers the following commands:

Undo	Reverse previous editing operation.
Cut	Deletes data from the document and moves it to the clipboard.
Copy	Copies data from the document to the clipboard.
Paste	Pastes data from the clipboard into the document.

3.3 View menu commands

View menu commands

The **View** menu offers the following commands:

Toolbar	Shows or hides the toolbar.
Status Bar	Shows or hides the status bar.

3.4 COM-Port menu commands

COM Port menu commands

The **COM Port** menu offers the following commands:

Choose COM Port	Opens the choose COM port dialog.

3.5 Repeater menu commands

Repeater menu commands

The **Repeater** menu offers the following commands:

Read Data	Opens the read data dialog.
Repeater	Opens the repeater settings dialog.

Settings	
Erase Memory	Opens the erase memory dialog.
Set Head Pos Threshold	Opens the set head position threshold dialog.
Calibrate Frequency	Opens the calibrate frequency dialog.

3.6 Base Station menu commands

Base Station menu commands

The **Base Station** menu offers the following commands:

Read Settings	Opens the read settings dialog.
Implant Surveillance	Opens the implant surveillance dialog.
Read Data	Opens the read data dialog.

3.7 Help menu commands

Help menu commands

The **Help** menu offers the following commands, which provide you assistance with this application:

Help Topics	Offers you an index to topics on which you can get help.
About	Displays the version number of this application.

4 status bar

Status Bar

The status bar is displayed at the bottom of the Pansen Repeater window. To display or hide the status bar, use the **Status Bar** command in the **View** menu.

The left area of the status bar describes actions of menu items as you use the arrow keys to navigate through menus. This area similarly shows messages that describe the actions of toolbar buttons as you press them, before releasing them. If after viewing the description of the toolbar button command you wish not to execute the command, then release the mouse button while the pointer is off the toolbar button.

The right areas of the status bar indicate which of the following keys are latched down:

Indicator	Description
CAP	The Caps Lock key is latched down.

NUM The Num Lock key is latched down.

SCRL The Scroll Lock key is latched down.

5 toolbar

Toolbar

The toolbar is displayed across the top of the application window, below the menu bar. The toolbar provides quick mouse access to many tools used in Pansen Repeater,

To hide or display the toolbar, click **Toolbar** from the **View** menu.