

Force Measurement on Regatta Yachts

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Problem Analysis and Concept

A sailing regatta is often a question of a small, but decisive winning margin. There is an optimization possibility in the trimming area. Up to now the force was determined intuitively. By the utilization of modern measurement technology, exact measurement results can be achieved and by this an optimized yacht trim as well.

Here it is a question of the force which acts on the backstay, adjustable steel-wire ropes for the mast trim in lengthwise direction. The measuring system at such a spot must be very robust, lightweight and must have a small power consumption.

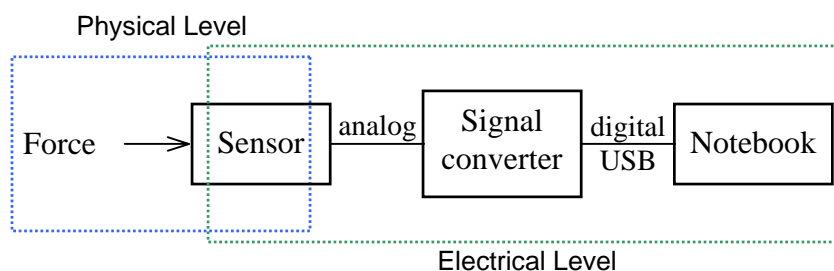
Within the framework of this project the force was measured by force sensor type K-100 and an USB amplifier of company LORENZ MESSTECHNIK GmbH.



Picture 1: Measured value acquisition of regatta yacht X79 at the Westküste

Function Principle

- The sensor is mounted between the tensioning-device (backstay-pulling tool) and the steel-wire rope (backstay) (Picture 2).
- The sensor signal is amplified through a signal transformer and converted from an analog signal into a digital signal. The amplifier is supplied through the USB-interface of the Notebook.
- The digital signal is transferred via USB to the Notebook, evaluated by the created software and stored in the computer.
- Data of the force sensor:
 - ⇒ Type K-100 by LORENZ MESSTECHNIK GmbH
 - ⇒ Nominal range: $\pm 5\text{kN}$
 - ⇒ Tolerance: 0,3 %

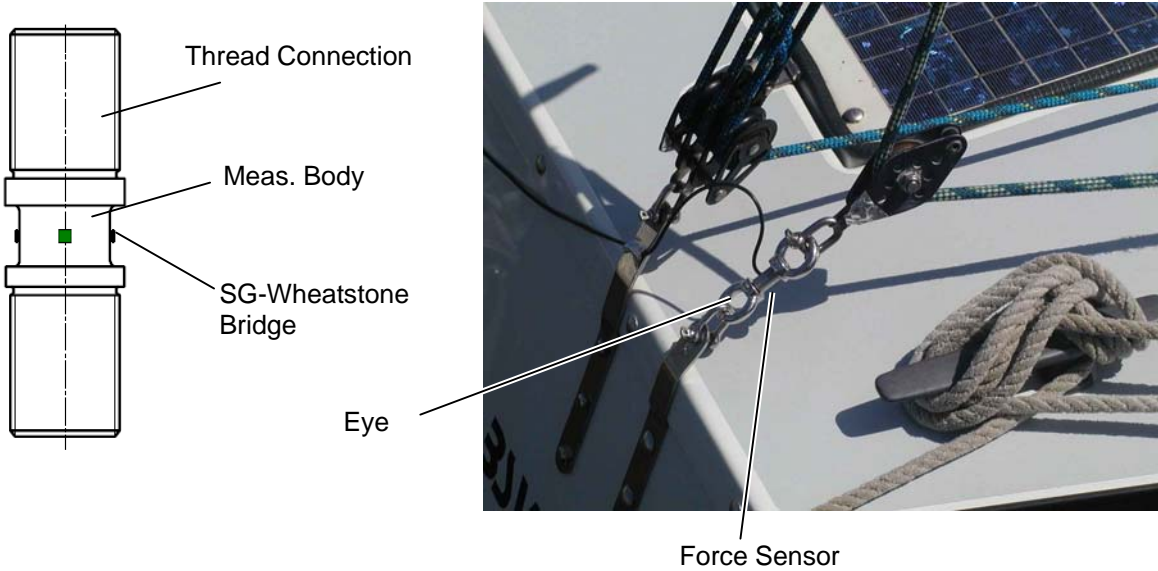




Picture 2: Installation of the sensor and practical load tests

The Force Sensor

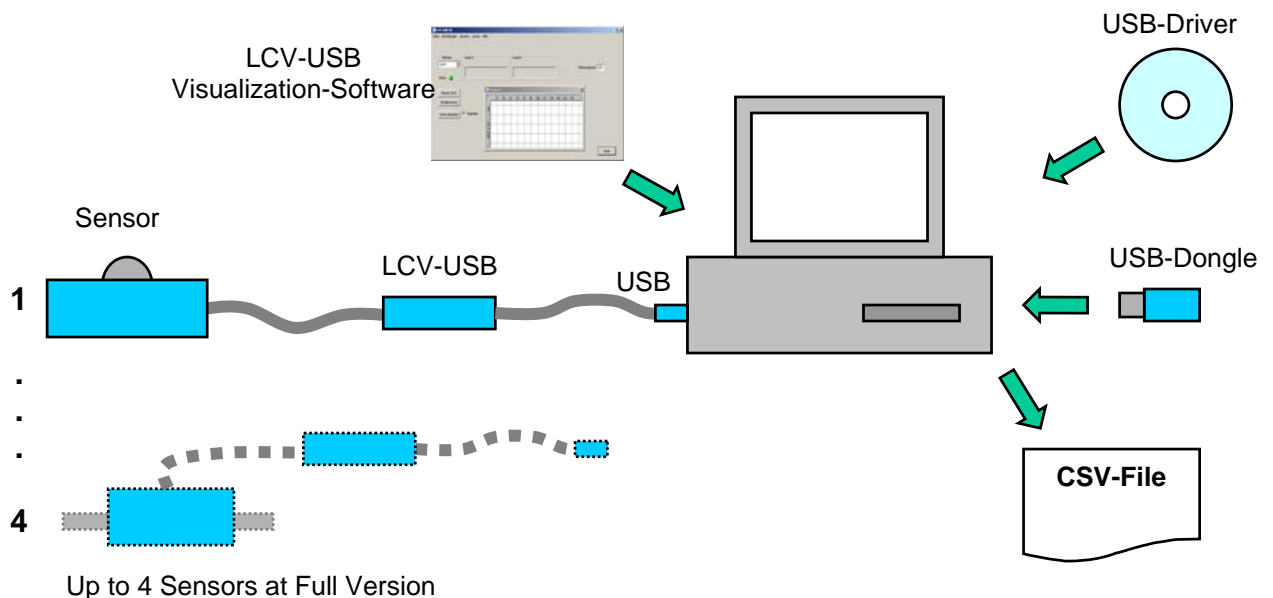
The tension force sensor K 100 consists of a measuring body bonded with a strain gauge Wheatstone bridge. The measuring bridge is directly connected to the LCV-USB. Threads are attached on both ends with a respectively screwed-in eye.



Force Sensor Schematic

Mounted Sensor

The Measuring Amplifier LCV-USB



Sensor Signals

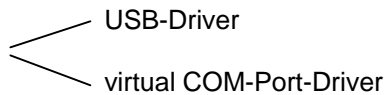
- mV/V (0 mV/V – 3 mV/V)
- V (0 V - 5 V)
- mA (0 mA – 20 mA)

Required components for the operation of the interface with the visualization software:

Sensor with LCV-USB

Visualization software run capable without installation

Installation of the driver for USB-Interface



USB-Dongle at Full Version

- Writing in file
- 3 additional LCV-USB's

Operation of the interface without visualization software:

Sensor with LCV-USB

Installation of the driver for the USB-Interface

Functions of the visualization software

- Setup of the LCV-USB
- Presentation of the measured data
- Output of measured data in a CSV-File

LabVIEW

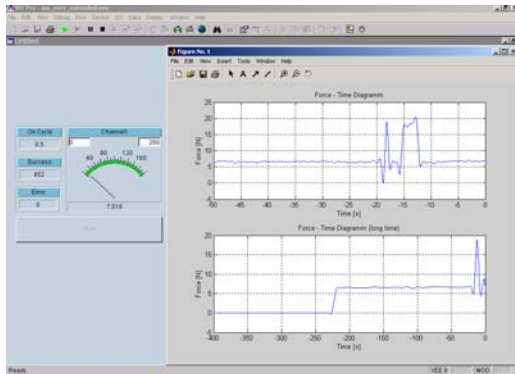
- LV-VI is present

Self-provided Software

- Protocol description for Sensor-Interface LCV-USB and for Sensors with RS485 (090110g.pdf)

Technical Realization

The force sensor is installed at the X 79 -regatta yacht and covered with an isolating-coat. By this, a protection against environmental impacts such as fast temperature fluctuations and direct salt water influences is accomplished. The measuring amplifier and the notebook were mounted shock-protected inside of the yacht. The PC communicates with the measuring amplifier of the sensor via the USB interface. The acquisition of the backstay-force is automated by the software Agilent-VEEpro and Matlab-Script (Picture 3). After the measurement was started, the current measured values with a measuring frequency of 2 Hz are received and visualized in a Quasi-Analog display. The measured values are recorded for archiving in a file. The course of the measured value is represented writer-functional and displayed as a long-term curvature by the assistance of a data reduction-algorithm. The number of successful and deficient transmissions are registered and displayed.



Picture 3: User interface for the the control and visualization of the backstay force measurement. Writer functionality: above: current measured values, below: long-term curvature.

Results

- The described force measurement was checked under laboratory conditions. Comparative measurements have confirmed the correctness.
- Both, the measured value acquisition and the recording of the measurement results with a Notebook were carried out successfully under real conditions. The measuring system resisted to humidity, to salt water and to high temperatures and vibrations.
- Picture 4 shows two different courses of the force characteristics at constantly held yacht trim and different regatta situations:
- Both characteristics show force peaks which are caused by waves and gusts.
- Differently strong decrease of the force is recognizable.

With the described force measurements it is possible to exactly determine and balance changes of the force. This can bring the decisive winning margin in a sailing regatta.

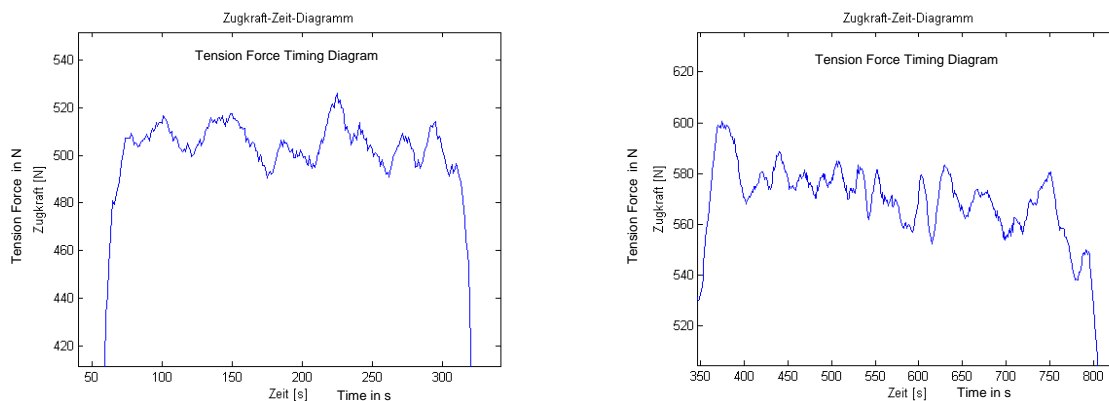


Bild 4: Constant Force (left) and Decreasing Force (right)