Real Time Underwater Sound Measuring System MAUI Delivers First Results

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Introduction

Underwater noise is one of the environmental key aspects when offshore wind turbines are installed at sea. In Germany there is a legal framework regarding noise emission control during underwater installations. A noise limit of 160dB re 1 µPa is given at a distance of 750m from the construction site and a thorough monitoring procedure is prescribed by the national authority BSH. It is demanded that the required reports on underwater noise are forwarded to BSH immediately after each construction is finished.
Against this background DEWI was contracted by Vattenfall Europe to set up a measuring system that is able to monitor the actual underwater sound during pile driving in "real time". Within the research project DEWI developed the underwater acoustic noise measuring system MAUI (**M**onitoring System for **A**coustic **U**nderwater noise including **I**nteractive Control and Data Transfer) which assesses the sound pressure levels during pile driving in real time.
The evaluated data is transferred instantaneously from the system located at the sea bottom to an optional vessel or platform located at the construction site. There the sound pressure level is presented graphically with a delay of only a few seconds after noise emission. A report on the pile driving noise can be generated automatically.

Hardware Setup

Data transmission within the water body is not as easy as in the air. Electro-magnetic waves only have a limited range within water. One way to transmit information through water is sonic transmission where the information is transported by sound waves. Another option is to use a surface buoy as a relay station. The information is then transported to the surface system through the mooring cable e.g. by an induction modem. Wireless radio connection brings the data from the surface buoy to the vessel.
In the project we started with both concepts:

- a fully wireless data connection using a commercially available acoustic modem and
- the indirect solution by using a wired connection via surface buoy.

In both cases the data connection is not able to transmit a high band width of data. Therefore recorded "wav" files cannot be transferred directly. This makes it necessary to perform data processing under water with the conse-

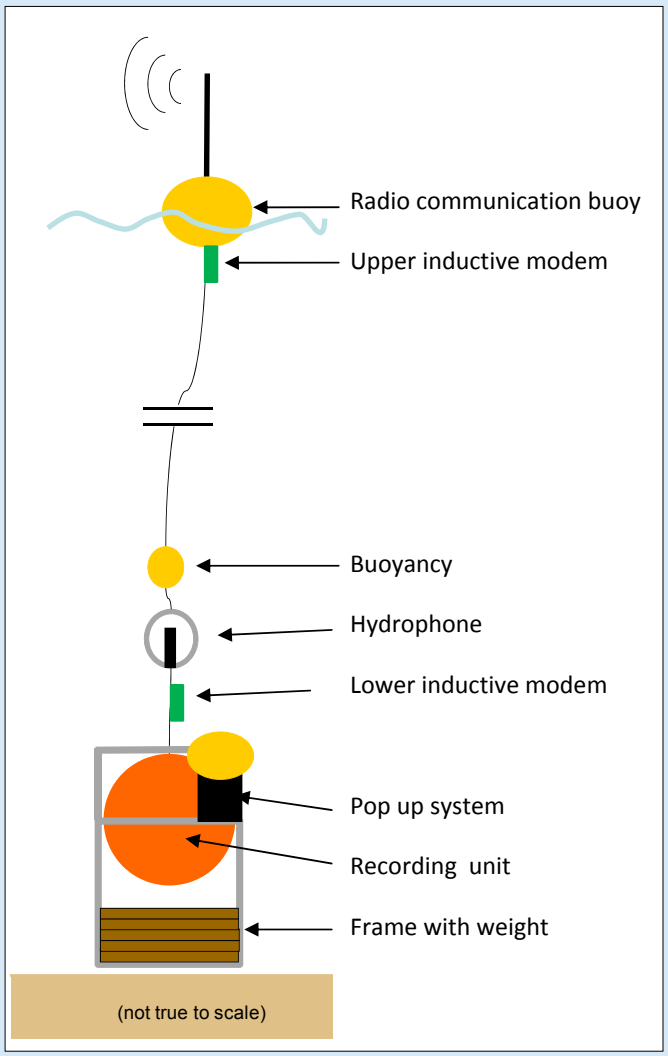

Fig. 1: Schematic set up of the "MAUI" system.

quence that not only a recording but also a more "intelligent" device (e.g. computer) is necessary to perform data processing. As a major disadvantage higher power consumption is needed for such a device.
First choice within the project was the acoustic modem option, as a system with no buoy on the surface provides higher durability of the system, lighter weight and a higher probability of withstanding bad weather conditions or vessel collisions.
Under the shallow water conditions of the North Sea the tests performed with the acoustic modem have not resulted in reliable and reproducible data connections within the requested range of 1km. As we expected further complications if the acoustic modem has to operate under the conditions of pile driving and the additional noise and screening effect of a bubble curtain the acoustic option was not further developed and the cable/radio option was chosen.
The realised prototype of the MAUI system consists of a bottom frame sheltering the housing for the computer, electronics and energy and a surface buoy equipped with an antenna, a radio modem and battery packs for the real time data transfer (Fig. 1). Both parts are combined with an isolated steel rope with a great breaking strength. Along with the steel rope the hydrophone is mounted 2.5 m above the sea floor.
The radio communication for data transfer between the surface buoy and a vessel is carried out on a frequency band needing no approval.

Software Setup

Data processing and analysis is carried out underwater directly after recording. After processing the amount of data has been reduced dramatically from gigabytes to only a few kilobytes per hour.
To allow standby times of several days to weeks energy saving is crucial. MAUI is equipped with a triggering circuit board that has been developed in house. It automatically starts the recording and processing only during times of pile driving. The trigger level can be adjusted according to the different project needs. The battery of the prototype is sufficient to allow more than 60 hours of measurements and several weeks of standby.
While the assessed parameters are immediately transferred to the vessel the uncompressed wave data still remain on the device and give the opportunity for later analysis. Un-

Fig. 2: Impressions from the offshore tests at alpha ventus and at Dan Tysk

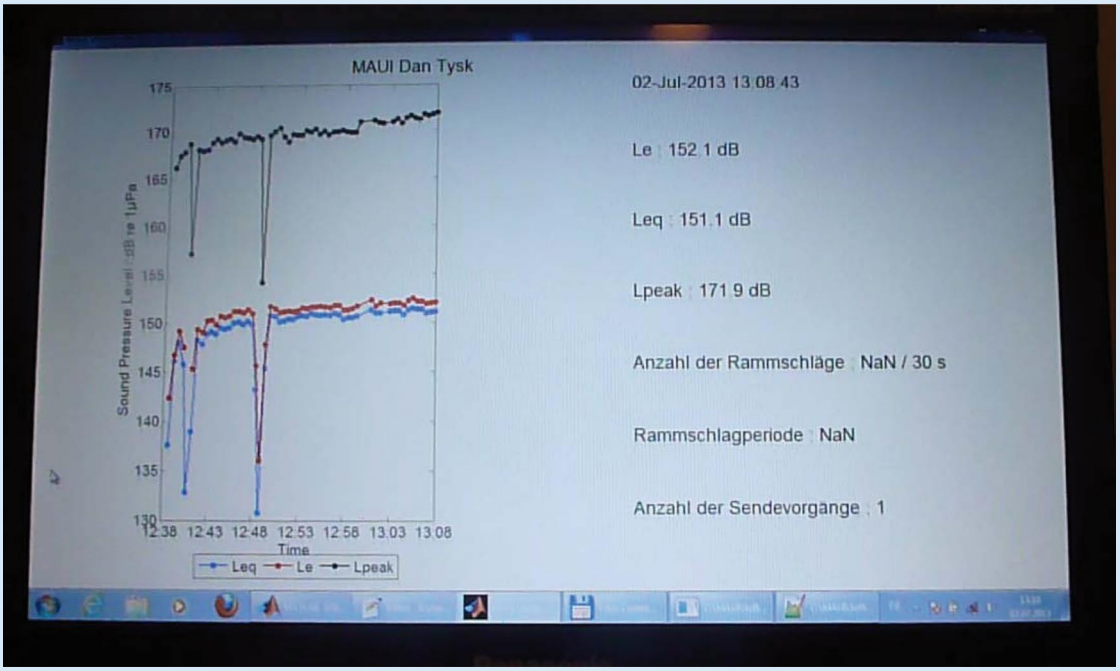

Fig. 3: Screen shot of the “MAUI” graphic display. The typically monitored noise levels SEL, Leq and Lpeak are displayed.

compressed sound data can be recorded for more than 500 hours.

Tests Performed

The system is mainly built up of standard parts, however different components and software modules have to interact accordingly to guarantee a reliable operation. Several tests have been carried out in order to obtain an offshore suitable system. First tests have been performed in the harbour area of Wilhelmshaven. They were used to learn and optimise the commissioning procedures, underwater performance and handling of the whole system. The first step under real offshore conditions has been carried out in the vicinity of "alpha ventus". Afterwards the handling of MAUI especially during the deployment and recovery was further optimised. The final test has been performed during an installation trip at Dan Tysk offshore wind farm in July 2013 (Fig. 2). Fig. 3 shows a screen shot of live data of the typically monitored noise levels SEL, Leq and Lpeak during pile driving. As additional information the number of pilings and the adjacent piling period are displayed. The number of transmission processes informs about the quality of the data connection.
During the test at Dan Tysk the prototype has shown its capability to perform reliably. Being a prototype it has to be handled by an experts team; however it is planned to further optimise the system for unattended use.

Summary

Within a research project the prototype of "MAUI" has been developed. The system allows automatic and immediate reporting of noise immission levels at offshore construction sites (e.g. at 750m or 1500m distance).
The MAUI system has further advantages

- Range of the data connection reaches up to 5 km
- Energy-efficient operation as measurements are only started during pile driving
- Automated reporting according to standards. Being an enclosed system of data recording, processing, transmission and display instant reports can be obtained without expert personal.
- Original data remains stored on the device for later verification

MAUI is the key for "at the site optimization" of noise mitigation systems (e.g. adjusting air pressure or volume of bubble curtain, testing of different hammer energies or setups, general detection of failures in the setup.)

This work was kindly funded by Vattenfall Europe Windkraft GmbH.

ELECTRICAL CHARACTERISTICS

DEWI carries out measurements and evaluations to determine the electrical characteristics of single wind turbines, wind farms, solar inverters and of other generating units/systems according to the currently applicable standards (e.g. IEC 61400-21). LVRT (Low Voltage Ride-Through) tests can be done with own equipment for generating units up to 10 MW (in grids up to 35kV). DEWI Wilhelmshaven is accredited for this service by "German Accreditation Body" (DAkkS) according to ISO/IEC 17025:2005 and is a member of MEASNET.
As one of the leading international consultants in the field of wind energy, DEWI offers all kinds of wind energy related measurement services, energy analyses and studies, on-/offshore wind turbine and component certification, further education, technological and economical consultancy for industry, wind farm developers and banks. DEWI GmbH is a member of MEASNET and is recognized as an independent institution in various measurement and expertise fields.