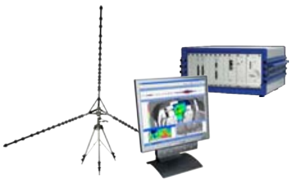
Application Note.
Free Field Measurements.

acoustic camera

System Characteristics



Array Star 48
48 microphones
3,40 m diameter
Foldable, 3-arms structure
Dynamic of the microphones: 35 dB -130 dB
Recommended mapping: 100 Hz – 7 kHz
Typical measurement distance: 5 – 500 m

Data Recorder
192 kHz Sampling frequency
48 to 144 channels per 10 inch rack (24 channels per card)
Ethernet Interface → high transfer rate → 20 MByte/s, network-compatible
Digital card with 12 extra channels for recordings of RPM, rotation angle, reversal point, etc.
Integrated PC with Windows XP (embedded)

Software
NoiseImage3

Power Supply
Mobile power supply / battery pack

2D Outdoor / Free field measurements

Free field mapping of wind turbine

With this application note the application of the Acoustic Camera for the analysis of wind turbine noise during operation in free field conditions is demonstrated. For this purpose a wind turbine has been analyzed at different wind speeds between 7 and 10 m/s. Those noise emissions have been identified and localized with the software NoiseImage that occurred on the back side of the wind turbine.

Application area

Acoustic analysis of big, free standing objects during operation in the free field

Measurement task

Outdoor mapping of wind turbine, Localization of sound in different frequency bands at different wind speeds

Measurement object

Wind power turbine (3 rotor blades, performance under 1 MW, height of mast 50 m, blade length 20 m)

Measurement set up

The entire set up of the Acoustic Camera on the ground took about 15 minutes. For the power supply a transportable, high-capacity battery has been used which offers a continuous operation of more than 4 hours. During measurements a relatively strong impact was coming from environmental noises which have been created by wind and local fauna. These background noises have been minimized by an A-weighting.

Fig. 1a and 1b Measurement object wind turbine and set up of the system

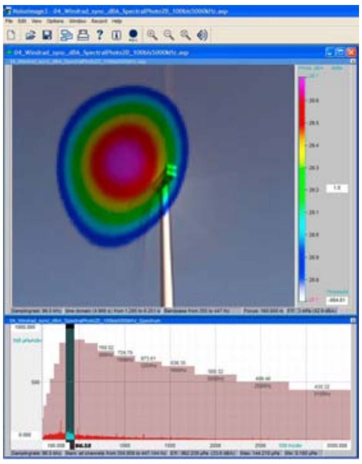


Fig. 2 Spectral Photo 2D with marked third octave band of 400 Hz and associated point of emission

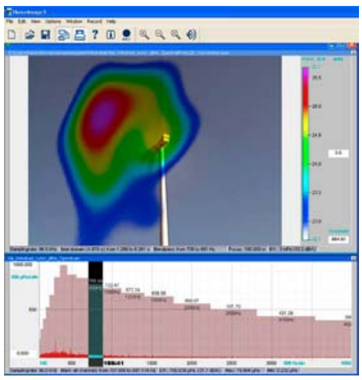


Fig. 3 Spectral Photo 2D with marked third octave band of 800 Hz and associated source locations at tip and at gear box

Results

Main goal of the analysis was to constitute a conclusion about the focus of the noise emissions on a wind turbine. First, results of the A-weighted data show the flow noise at the blade tips which is depended on wind direction and wind turbine location in association with the position of the Acoustic Camera. For the measurement the Acoustic Camera has been positioned slightly on the left behind the wind turbine. During the analysis of the blade noise the acoustic focus was located to the left of the gear box which is the side with the shortest distances to the microphones.

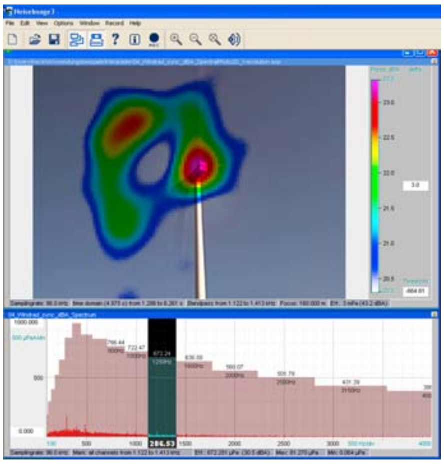


Fig. 4 Spectral Photo 2D with marked third octave band at 1.122 to 1.413 Hz and corresponding noise sources

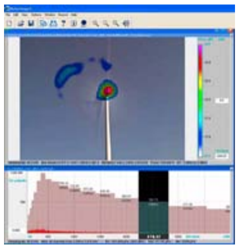


Fig. 5 Spectral Photo 2D with marked third octave band at 2.239 to 2.818 Hz and corresponding noise sources

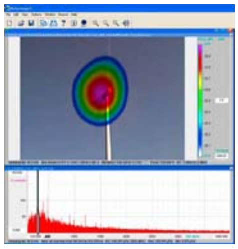


Fig. 6 Spectral Photo 2D with marked peak of 286 to 312 Hz and corresponding noise source

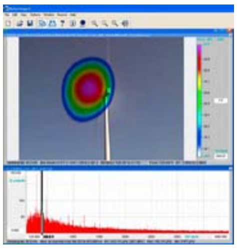


Fig. 7 Spectral Photo 2D with marked peak of 387 to 413 Hz and corresponding noise source

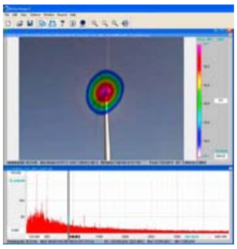


Fig. 8 Spectral Photo 2D with marked peak of 1.204 to 1.230 Hz and associated noise source

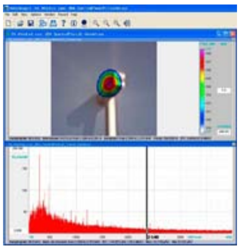


Fig. 9 Spectral Photo 2D with band pass of 2.350 to 2.371 Hz, associated source found at the left side of the gear box

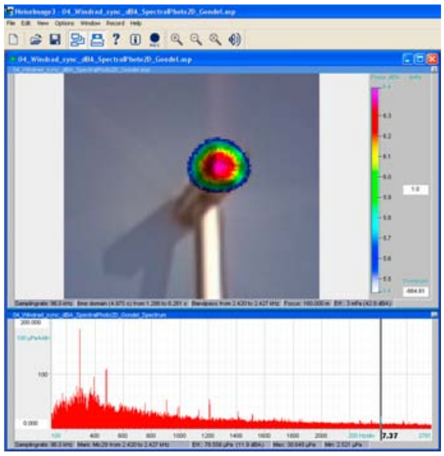


Fig. 10 Spectral Photo 2D with band pass of 2.420 to 2.427 Hz, associated source located directly on back wall of gear box

For a comprehensive analysis a whole revolution of one blade has been taken as calculation base. For the analyses the software module Spectral Photo 2D has been employed, which offers a pre-calculated location of the emissions for any frequency. The analysis led to the fact that the point of emission strongly depends on the observed frequencies.

For the third octave band of 400 Hz the emission can be located clearly at the root part of the blade while this blade is turning downwards located at 140 degrees (see fig. 2).

Looking at the frequency band from 706 to 891 Hz it becomes obvious that the blade tips and also the gear box are emitting this flow noise (see fig. 3).

In Figure 4 and 5 it becomes obvious that the higher frequencies are mainly emitted at the gear box while at the same time the hissing noises become visible as more quiet sources on the blade tips.

For further analysis a narrow band analysis was conducted – also with the help of the function Spectral Photo 2D. For this reason the noise origin of the single peaks in the spectrum has been analyzed. These emission sources are displayed in figures 6 to 8 while it becomes clear that the main source for this sine wave noise is the gear box.

Due to these results a focus has been put upon the gear box itself. For the focusing onto a special part of the measurement object it is not necessary to conduct a new measurement. The part of interest can easily be chosen during post-processing. By this proceeding it becomes clear that even at great distances it is possible to trace back certain frequencies to different emission points, exemplarily shown in figure 9 and 10. In order to analyze the parts of the gear box themselves it is advisable to conduct a more detailed analysis from a shorter distance, possibly on a test bench.