

# Application Information - DAM-XY01

## Structural Vibration Monitoring SVM

This note describes the application of the Gram & Juhl A/S DAM-XY01 vibration guard to monitoring structural vibrations in large wind-turbines.

Wind-turbines have grown in size to above 2 MW nominal power. This naturally puts focus on the wind turbines tower construction. All though mechanical design engineers optimise towers with respect to structural resonance and blade-passing frequencies, it is difficult to foresee the actual movement of the tower in turbulent wind conditions. This practical difficulty calls for monitoring of the tower's movement in the XY plane, possibly involving logging versus power and metrological data and firing alarms in case of critical movements.

Some of the difficulties involved in monitoring the structural movements of the wind turbines are:

1. Structural movements are very low-frequency (down to 0.1Hz)
2. It is desirable to separate non-relevant components from the tower's structural movement. Such components include transient events caused by blade-passing (also low-frequency) and high-frequency components originating from e.g. the gear and the generator
3. Both single- or omni-direction monitoring may be called for
4. Monitoring must be integrated with the wind-turbine controller



Figure 1: The DAM-XY01 sensor

This note explains how the DAM-XY01 sensor can help you overcome these difficulties in a cost-efficient yet advanced way.

## Integrating the DAM-XY01 with the wind-turbine controller

In its simplest configuration, the DAM-XY01 is integrated with the existing equipment via simple electrical interfaces. The DAM-XY01 has a solid-state relay output with a fail-safe mode of operation. In case of an alarm condition, this is signalled to the WTC (Wind Turbine Controller) via the relay. Optionally, the DAM module can output a voltage in proportion to the tower's maximum displacement. This voltage can be used to log the tower's displacement as a part of the existing data logging.

## Application Information - DAM-XY01

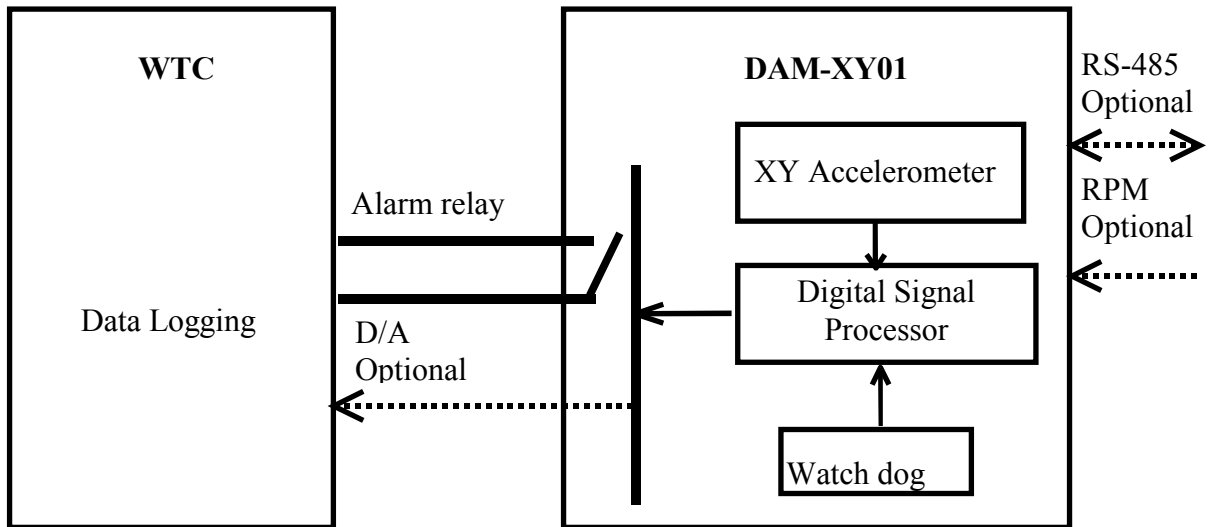


Figure 2: Integrating the DAM-XY01 with the Wind Turbine Controller (WTC).

### Configuring the DAM-XY01 for monitoring the tower's motion

The DAM sensors come with a Windows based configuration utility that can be operated remotely via a dial-up connection, if required. The Windows software is delivered free of cost with the DAM sensor.

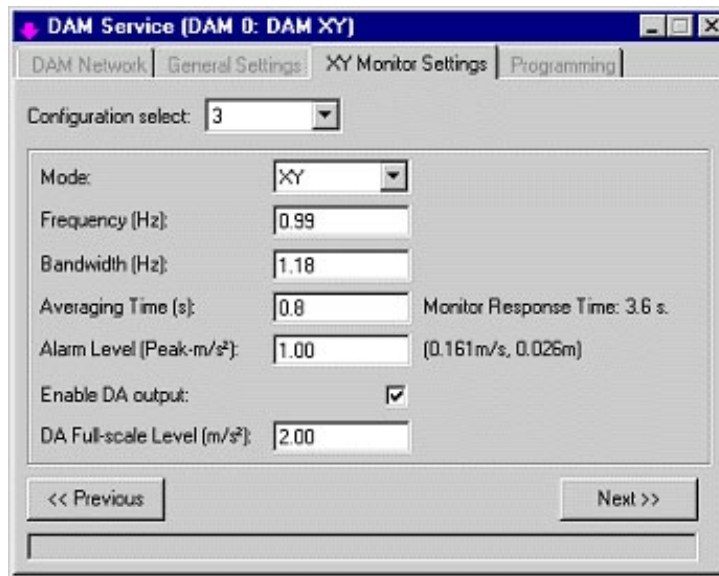


Figure 3 DAM Configuration utility: DAM-XY01 monitor settings

The DAM-XY01 module has settings for advanced monitoring of structural displacements. If any of the set alarm levels are exceeded, the module's solid-state relay is opened. The relay remains closed if no alarms are configured/activated.

**A total of 4 independent frequencies can be monitored simultaneously.**

# Application Information - DAM-XY01

Configuration Select	Selects which of the four independent alarms that are currently being configured. Each of the four alarm frequencies have independent settings
Mode	Selects the alarm mode: OFF Inactive X Sense in the X-direction only Y Sense in the Y-direction only XY Sense in both X and Y directions (omni-directional, i.e. detect the major axis of an elliptical movement)
Frequency	Select the frequency to be monitored. Note that the available resolution depends on the set bandwidth. The frequency can be selected in the range 0.01-128.00 Hz
Bandwidth	As a unique feature of the DAM-XY01 module, the bandwidth of the monitor can be defined. This means that even closely spaced components can be resolved and that high- and low-frequency noise can be discarded. The alarm band is centered symmetrically around the set frequency. The set bandwidth is the 3dB bandwidth of the detector filter ( $BW_{3dB}$ ). Other measures of the filter are: 1 dB cut-off: $0.94 \cdot BW_{3dB}$ 20 dB cut-off: $1.17 \cdot BW_{3dB}$ 40 dB cut-off: $1.26 \cdot BW_{3dB}$ 60 dB cut-off: $1.30 \cdot BW_{3dB}$ Note that reducing the bandwidth affects the Monitor response time in inverse proportion.
Averaging Time	The monitor will continuously measure the level using a sliding technique. The averaging time can be specified. Note that the bandwidth determines the lower limit for the averaging time and that the response time is increased in direct proportion to the averaging time. Also note that the events to be monitored should be stable for at least the duration of the averaging time.
Alarm Level	The alarm threshold level can be specified in units of acceleration ( $m/s^2$ ). Note that the alarm level refers to the peak values of a sinusoidal movement. For your information, the corresponding peak values of velocity (unit m/s) and displacement (unit m) are given. The lower alarm level is $0.02m/s^2$ , which corresponds to movements in the millimetre range at 1 Hz.
Enable DA output	The DAM-XY01 module has an analogue output voltage that can be controlled by one of the monitors. A voltage proportional to the actual level is output. The full-scale level (5Volt output) can be specified.
Response Time	The response time is defined as the duration from the onset of a sinusoidal movement at the detector frequency until the detector reaches 90% of the applied level. The DAM-XY01 module implements specifically tuned filters for obtaining a fast response. A faster response time can be expected if the alarm level is set lower than 90% of the tolerated level (which on the other hand may result in false alarms)

## DAM-XY01 Signal Processing

The DAM modules incorporate a built-in signal processor that allows for advanced measurements. These possibilities have been fully exploited for the DAM-XY01:

1. Unwanted frequencies and noise can be filtered out
2. The response time of the sensor has been optimised to achieve the fastest response possible using tuned filters and running average. The response time can be effectively controlled via the averaging. This allows to tune the device for a minimum event duration before triggering the relay output
3. The DAM-XY01 provides a true real-time motion monitoring: It is guaranteed that no events are lost. This is even achieved with advanced analysis running simultaneously (see below)

## Advanced monitoring

The DAM-XY01 can operate in a number of configurations

# Application Information - DAM-XY01

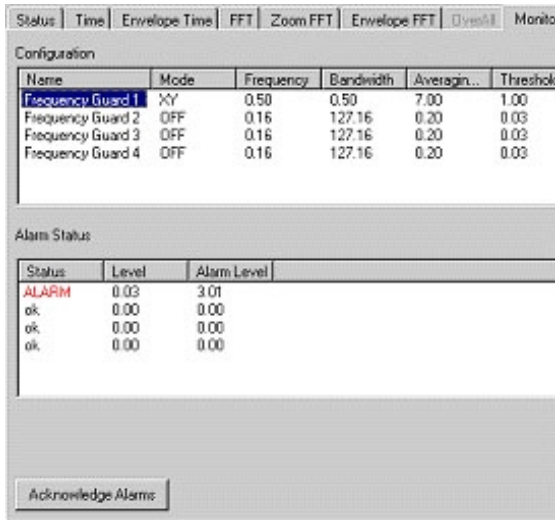
## Stand-alone operation with electrical interface to WTC

This configuration has been outlined above. It assumes that the DAM unit has been configured properly as described above prior to installing it in the wind turbine. The DAM then only needs power for proper operation. In case of a power cut-out or other unexpected behaviour, the alarm relay will be triggered.

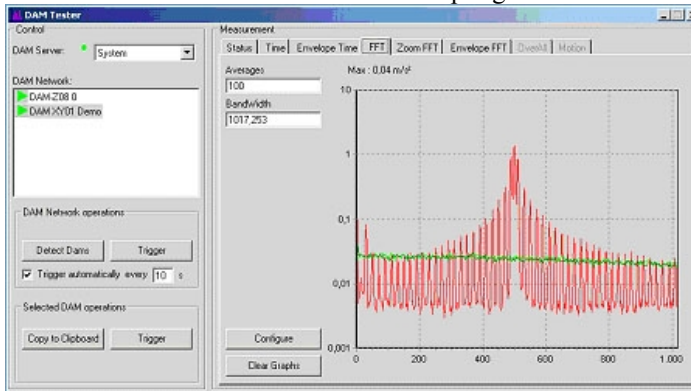
## Connect a PC for configuration, analysis or service

A PC can be connected to the DAM-XY01's RS-485 interface. The sensor comes with a software package for Windows 2000/XP that gives advanced control of the sensor:

- 1) Configuration, as described above
- 2) Monitoring of Alarm Status. You can see the status of the individual frequency guards, the actual level and the measured level at the time of triggering the alarm relay:



- 3) On-line analysis while monitoring is running. This unique feature gives you the possibility to analyse the vibrations of the sensor with e.g. an FFT analysis or a motion pattern analysis. Such analyses can be made without interrupting the monitor functionality.



- 4) All of the above Windows applications are build using DCOM and ActiveX technologies, which means that you can easily build your own monitoring application on top.

## Dial-up operation for alarm monitoring

A PC can be connected to the DAM-XY01 module. This PC runs a server application that allows for Dial-up access to the DAM sensor. There are no restrictions to what you can do to the sensor using a dial-up connection compared to what you can do on-site.

## On-line operation as a part of an advanced machine-monitoring network

The RS-485 interface of the DAM unit allows for hooking up to 32 DAM units up into a single network, possibly controlled by a PC as described above. The network can consist of any types DAM modules. The interested reader is referred to Gram & Juhl's Web page, <http://www.gramjuhl.dk>.