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Development of a Data Acquisition System for the CM of a wind turbine

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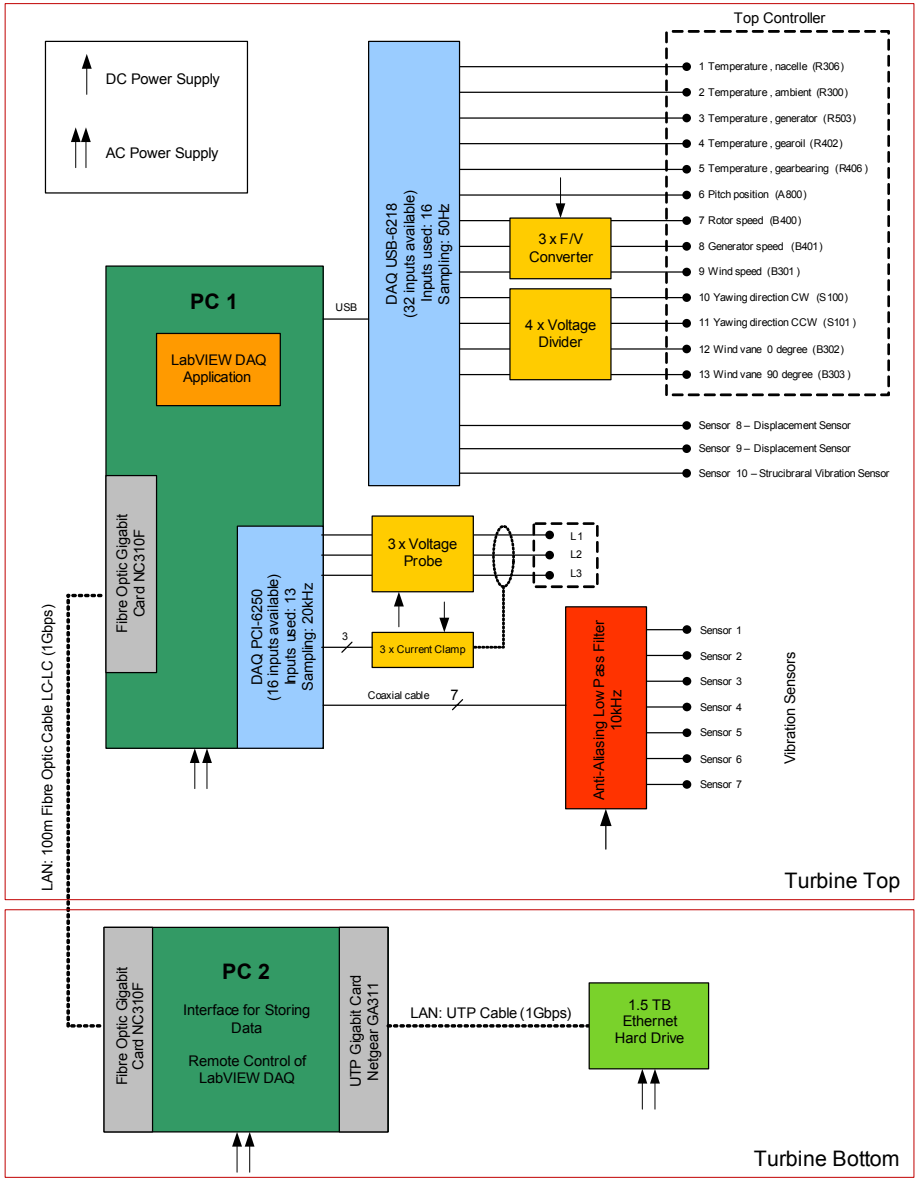
Summary:

- Update on the progress of the Data Acquisition Platform.
- Brief overview of previous work for PROSEN project.



Data Acquisition Platform Layout

To be installed on a Vestas V47 (660kW) WT at Harehill

Building the DAQ Platform:

- Design of physical setup so that it conforms to operational and safety regulations.
- In order to do this we must anticipate conditions and scenarios the system may be exposed to and must be capable of handling
- The aim is to put together a working prototype in the lab as a demonstrator for Scottish Power to gain their approval.
- A number of issues encountered

Sensors

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No	Parameter	Output	Interface	Sampling Rate
1.	Temperature, gear bearing	PT100	Sig. Condt.	50Hz
2.	Temperature, generator	PT100	Sig. Condt.	50Hz
3.	External Air Temperature,	PT100	Sig. Condt.	50Hz
4.	Temperature Nacelle	PT100	Sig. Condt.	50Hz
5.	Temperature gear oil	PT100	Sig. Condt.	50Hz
6.	Rotor speed (Hall effect gear tooth sensors)	Hi-pulse	Labview	50Hz
7.	Generator speed (Hall effect gear tooth sensors)	Hi-pulse	Labview	50Hz
8.	Pitch position (linear actuator)	0-10V	Direct	50Hz
9.	Atmospheric Pressure	0-5V	Direct	50Hz
10.	Wind speed (nacelle mounted wind anemometer)	Hi-pulse	F/V Converter?	50Hz
11.	Digital compass (nacelle direction)	Compass Bearing	RS232	8Hz
11.	Wind direction (wind vane)	0-5V	Direct	50Hz
12.	Structural Vibration - XY	±5V	Direct	20kHz
13.	7 Hansford vibration sensors	±5V	Filtered	20kHz
14.	3 Phase Currents	±5V	Direct	20kHz
15.	3 Phase Voltages	±5V	Direct	20kHz

Issues cont.

Interfaces For sensors

High speed 20kHz sensor readings

Interfaces For sensors

Low speed 50Hz sensor readings

Exception handling

8Hz compass bearing data stream

Labview DAQ program

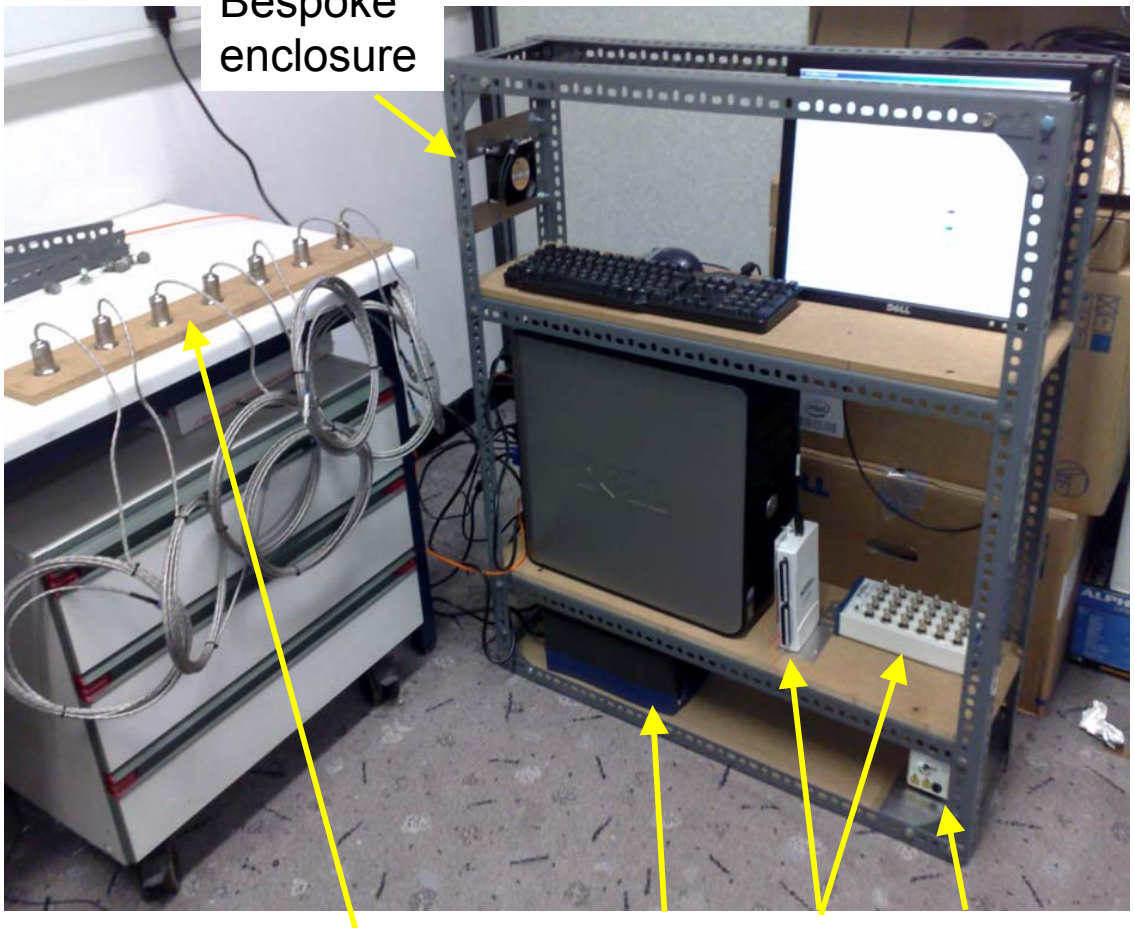
Start time – End time
Data Acquisition loops

Time stamped High speed Database

Time stamped Low speed Database

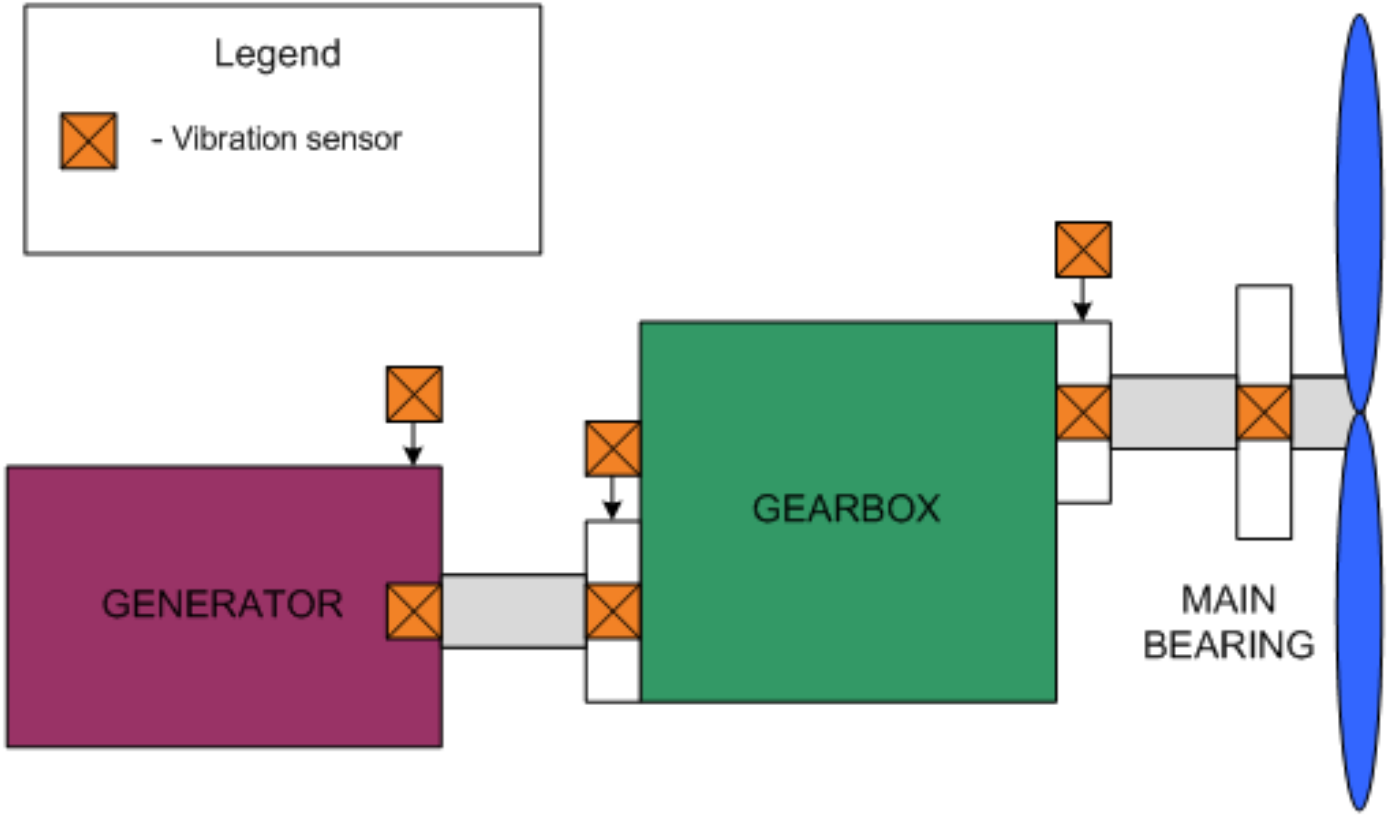
Time stamped Digital Compass Database

Nacelle enclosure and test rig:



Anemometer, wind vane, air temperature and humidity

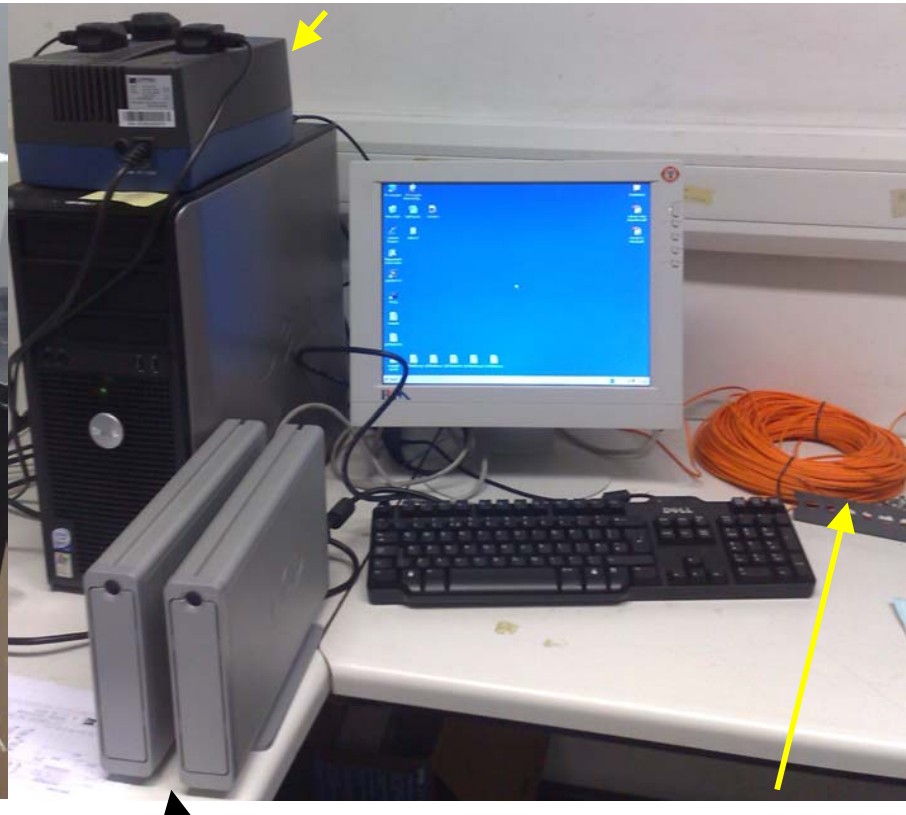
Hansford HS-100 Vibration Sensor Layout



Bottom enclosure:

Off the shelf enclosure

UPS



2 x HDD

Optical Fibre link

Link with PROSEN Project

- Past ESPRC Project looking at wireless sensing (applied to WTs). Consortium: Lancaster, Stirling, Essex and Strathclyde University. (Industrial partner Scottish Power)

- Given access to almost 2 years worth of SCADA data acquired from Hagshaw Hill wind farm consisting of 26 Bonus 600kW turbines pitch regulated turbines.

- Process the data to investigate any interesting events.

Motivation for research

- Integrated CM system uses a variety of sensors monitor different components of the turbine.
- Data is collected and stored centrally via SCADA systems.
- Currently data is analysed by an operator who must deduce the health or state of a component.

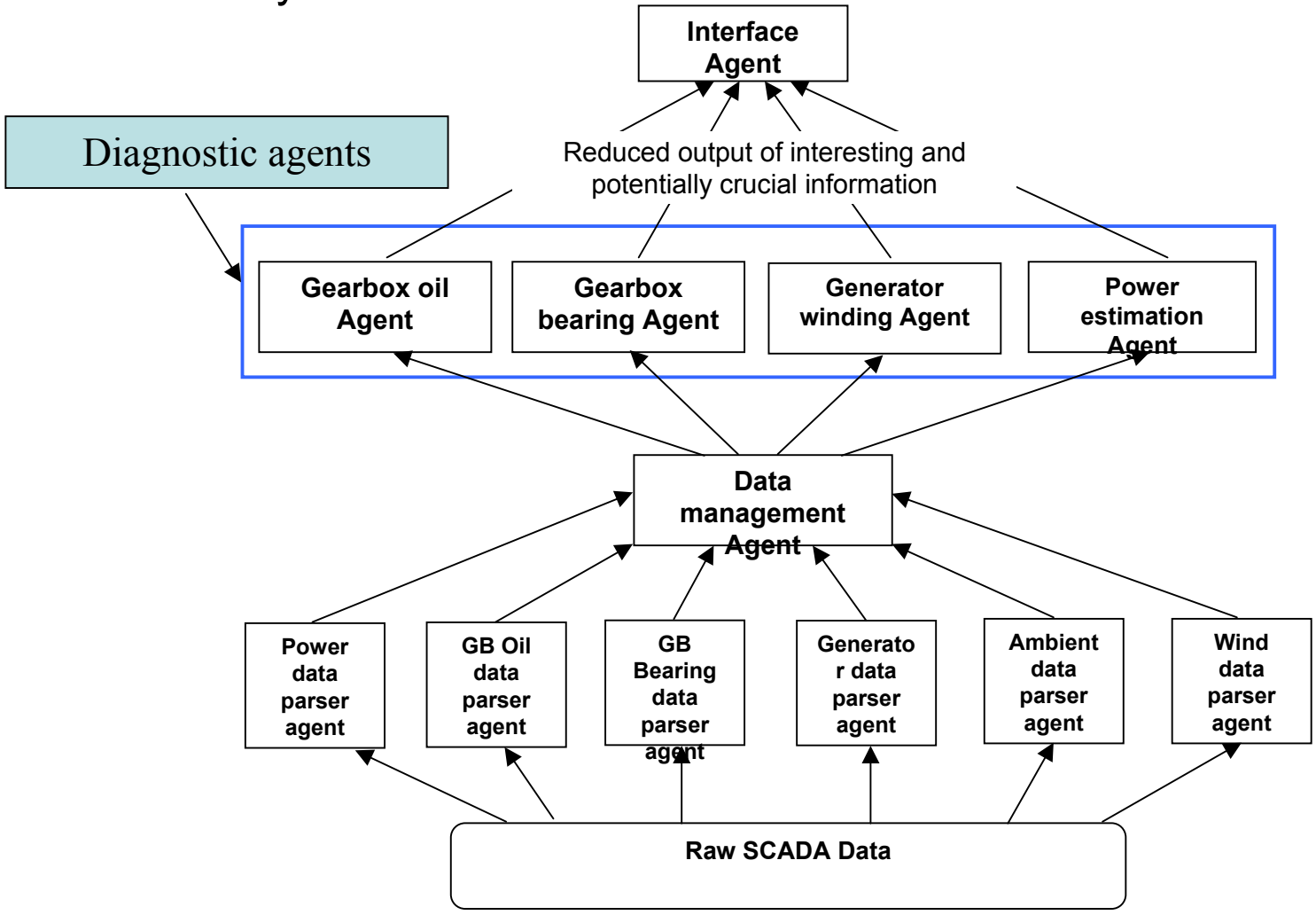
Two main issues

1. Volume of data Generated
2. Need for trained operators

Typical parameters:

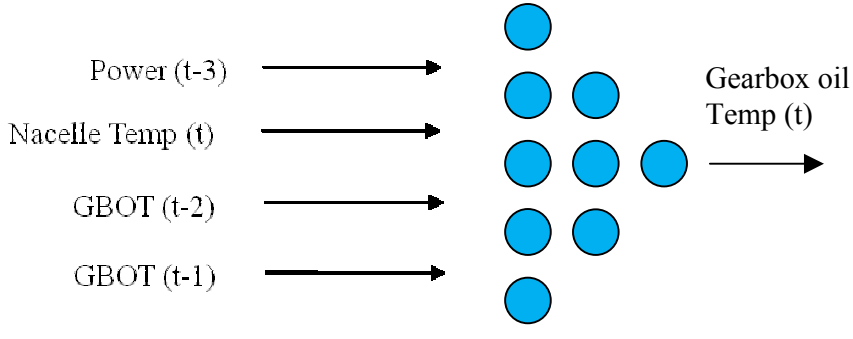
active power, rotor speed, wind speed, gearbox oil & bearing temperature, generator temperature, nacelle temperature

Working Prototype Architecture: A Multi-Agent Fault detection system.



Normal behaviour modelling: (temperature anomaly detection)

- Utilises a back propagation neural network for learning normal behaviour models for the temperature of components.
- Currently tested on gearbox and generator.



- Captures the non-linear relationships between the parameters
- Provides an estimation of expected temperature of component which can be compared to actual temperatures.

Results after training: anomalous readings found

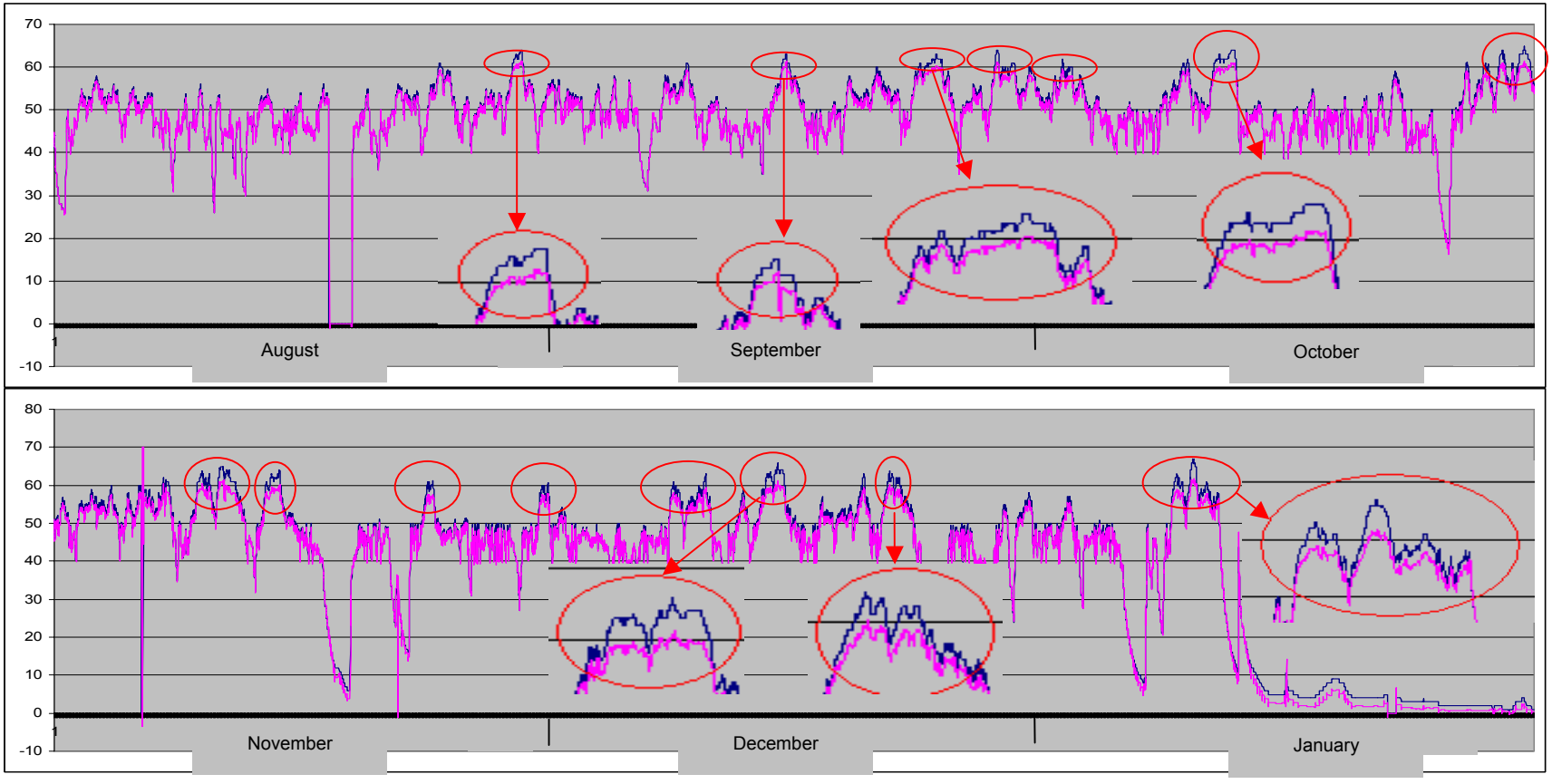
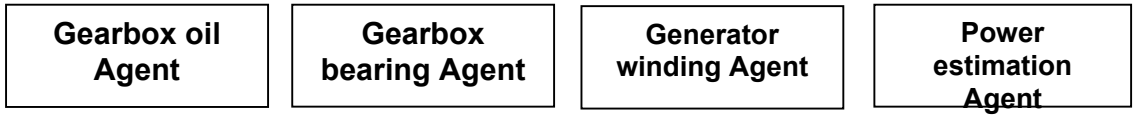


Figure 4: gearbox failure: *cooling oil anomalies detected from aug05 – jan06*

Corroboration of output

- Output of both bearing and oil models can be used in conjunction with one another to help identify the source of the problem e.g. Main bearing or internals

- Generator problems can be identified before they begin to affect power output but when used with power output model it can be used to identify point in time when power output is affected.



- This will prove useful especially for more parameters sampled at higher frequency.

SGV – Condition Monitoring at UoS

- Once Harehill data recorded, will have increased sensor data – both more parameters and much higher resolution data than SCADA
- Will apply techniques learned during PROSEN to SGV data
- Investigating data relationships and health/condition of WTs
- Will attempt to corroborate any ‘events’ with SCADA data
- Detailed data will aid diagnosis initially and prognosis ultimately

Future Work

- Digital compass data acquisition incorporation into original program.
- Internal Wiring of sensors to power supplies and DAQ units
- Mains & reset switches, enclosure fuse's, and power LED's
- Build Sensor Interfaces
- Individual sensor tests (with interface)
- Overall system test.
- Invite SP for a demo.

- Question:
  - Are there any other parameters that we should try and monitor?

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Published Publications

- Swiszcz G., Cruden A., Booth C., Leithead W., "A Data Acquisition Platform for the Development of a Wind Turbine Condition Monitoring System", International Conference on Condition Monitoring and Diagnosis 21-24 April 2008, pp 1358-1361.

Submitted Abstracts

- Zaher A., Cruden A., Booth C., Leithead W., "High Resolution Wind Turbine Condition Monitoring", World Renewable Energy Congress (WREC 2009 - Asia) incorporating the 3rd International Conference on Sustainable Energy and Environment SEE(2009), 19-22 May.

- Zaher A., Cruden A., Booth C., Leithead W., "Database management for high resolution condition monitoring of wind turbines", 44th Universities' Power Engineering Conference (UPEC), 1-4 September 2009.