

# Vibration Analysis of Gearbox and Generator of a 25kW Wind Turbine

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# The Turbines

25kW, 2-bladed

Self-yawing, Downwind machines

Guyed towers

Lowered for maintenance at ground level

Very old – 1989

Noisy blades and gearbox!

Induction generator

Full electronic conversion AC→DC→AC

= variable speed 43 Hz to 50 Hz

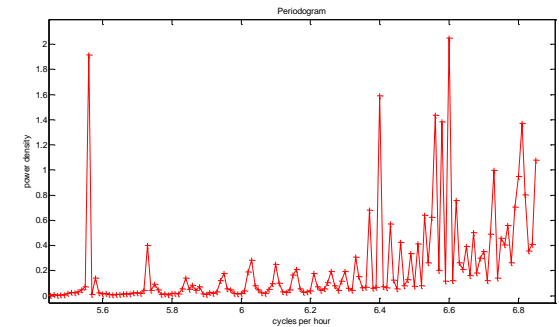
Only one turbine has been instrumented



Fig – Wind turbines  
At West Beacon Farm  
[www.beaconenergy.co.uk](http://www.beaconenergy.co.uk)

# Aims Of Project

- Detect vibration via electrical power signal
- Compare power signal vibration with accelerometer signal
- Detect developing gearbox faults as growing vibration amplitudes
- Develop a Condition-Based maintenance scheduling method
- Reduce unplanned outages



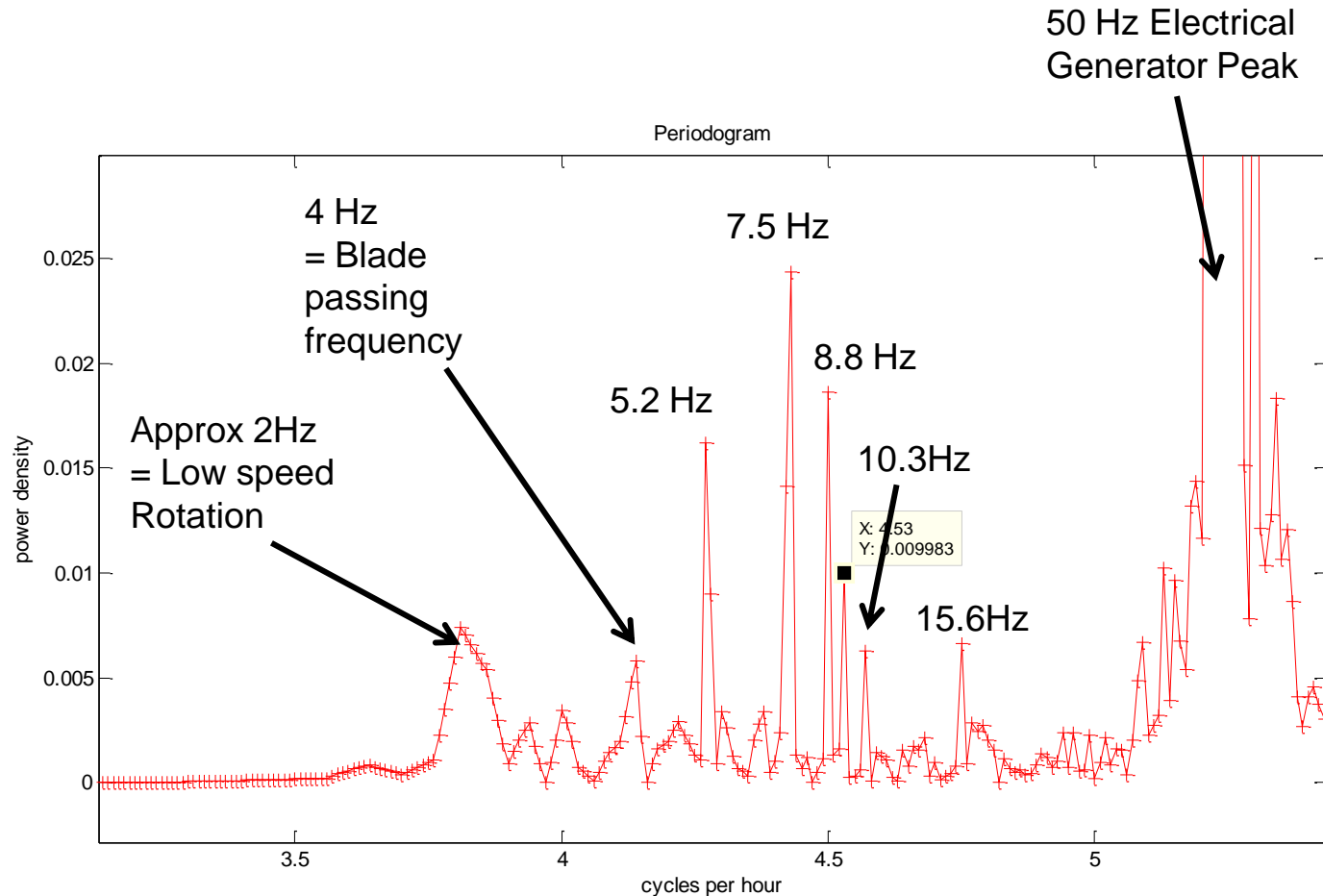
Fast Fourier  
Transform of  
Accelerometer  
Signal

# Instrumentation and Logging

- 6 Accelerometers on the Gearbox
- 3 Current Sensors (Ammeters)
- 3 Voltmeters
- 4kHz data in 5 second bursts
- So range is 1 Hz to 2 kHz

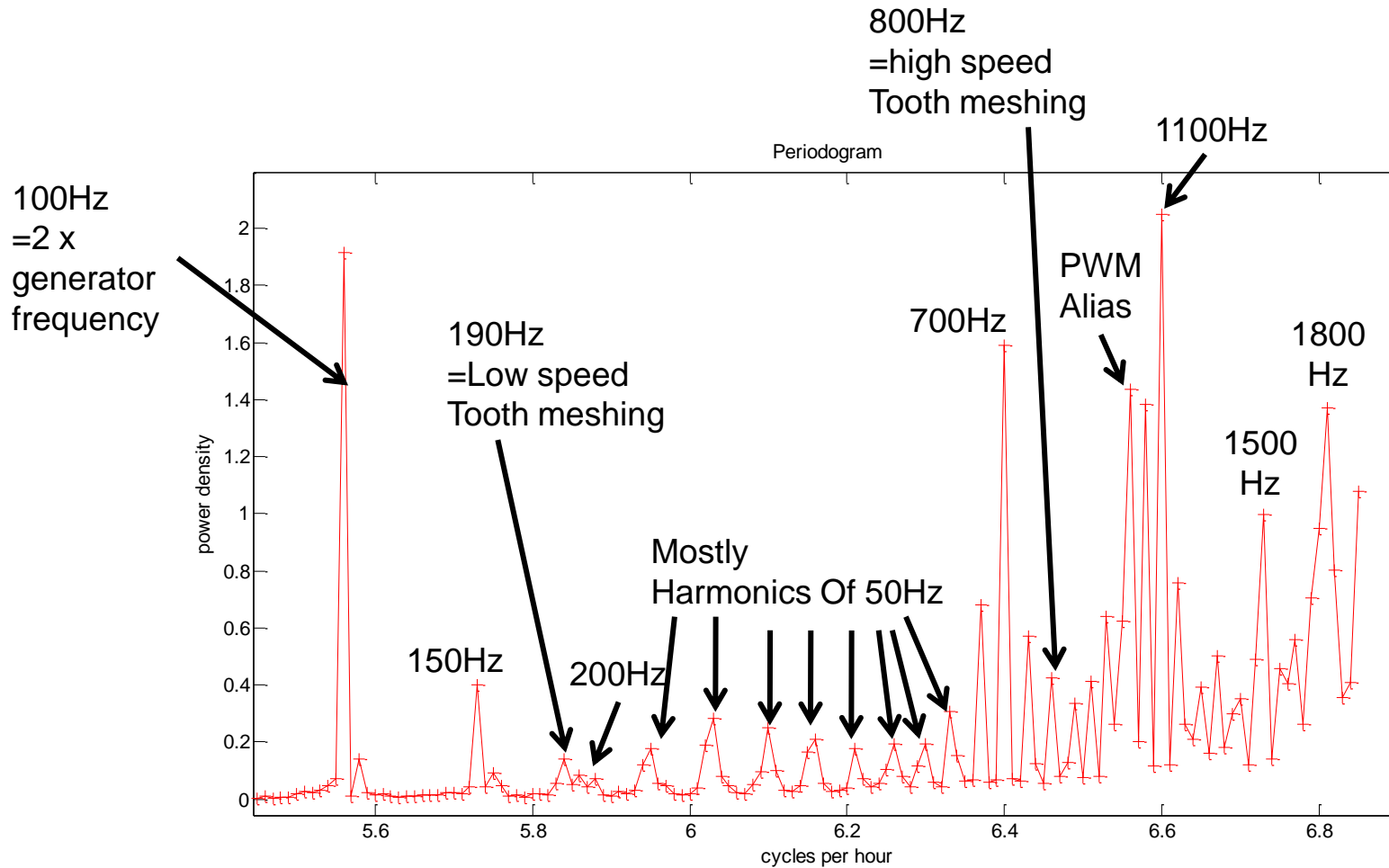


# Fourier Transform of Each Channel - Typical Low Frequency End of Spectrum



# Fourier Transform of Each Channel

## - Typical High Frequency End of Spectrum



# Initial Manual Examination of Fourier Transform

Columns Represent Signal Channels

Key

- Small peak
- Strong peak
- Enormous peak

Accelerometers

Electrical signals

Increasing Frequencies

	0.1073	0.13796	0.097826	0.76511	0.002941	0.77417	0.002319	0.43888	0.002293	0.53765			
	0.12871	0.10656	0.11984	2.1296	0.003974	2.2819	0.00302	1.0471	0.00287	0.77561	11 X electrical frequency		
	0.093109	0.10221	0.080545	1.0153	0.002695	0.89019	0.003232	0.70418	0.002274	0.28335			
	0.078965	0.070886	0.077293	0.72306	0.003318	1.0992	0.002476	0.49197	0.002444	0.23464			
	0.22986	0.31442	0.22051	1.3958	0.003617	1.5836	0.003035	0.81314	0.002862	0.89592	12 X electrical frequency		
	0.11203	0.09787	0.092451	0.91909	0.003272	0.84681	0.002984	0.41209	0.002224	0.71983			
	0.077195	0.089696	0.09452	1.2702	0.00284	1.2177	0.003344	0.90384	0.003979	0.35456			
	0.088343	0.11048	0.07553	0.82877	0.003265	0.7277	0.00243	0.42323	0.002566	0.35373			
	0.55125	0.54109	0.38925	6.3943	0.008651	6.5848	0.005338	3.9214	0.008024	0.94982	13 X electrical frequency		
	0.073139	0.072476	0.064825	0.91068	0.003114	0.84913	0.002694	0.60198	0.002849	0.25671			
	0.063637	0.092181	0.061642	0.79387	0.003545	0.89554	0.002542	0.57465	0.003893	0.2505			
	0.98564	1.1555	0.81498	14.091	0.006983	13.562	0.007135	7.5024	0.00686	1.8508	14 X electrical frequency		
	0.10614	0.12415	0.10189	0.81855	0.003169	0.5753	0.003148	0.38877	0.003153	0.41123			
	0.063542	0.1012	0.066925	0.55653	0.003353	0.58092	0.003012	0.47286	0.003591	0.2343			
	0.47357	0.40034	0.31818	2.6904	0.00514	2.7387	0.003993	2.2874	0.004262	0.58209	15 X electrical frequency		
	0.22393	0.2574	0.21356	1.3983	0.004229	1.5291	0.004154	0.61376	0.003979	0.321			
	0.073646	0.093769	0.073547	1.0907	0.003261	0.96125	0.003491	0.55467	0.003235	0.31904			
	0.42277	0.54409	0.40053	1.7769	0.006488	1.6652	0.004674	0.80862	0.005149	0.6513	High speed tooth meshing frequency		
	0.1226	0.14116	0.11334	0.55014	0.00402	0.657	0.003577	0.40859	0.00336	0.22888			

# Results

- Most big spikes show up in most channels  
– they are real!
- Some frequencies can be identified:
  - Blade passing frequency
  - Generator frequency
  - Power electronic noise at PWM frequency
  - Tooth meshing frequencies?
- But many are unknown
- Most large accelerometer signals also show up in electrical data – good!
- So electrical output **can** detect vibration



# Next Steps

- Look at other rotation speeds
- Natural frequencies vs. Forced frequencies
  - ↓
  - Don't change with  
Rotation speed
  - ↓
  - Do change with  
Rotation speed
- Automate detection of vibration frequencies
- Calculate natural frequencies using 'Bladed' software from Garrad Hassan and compare
- Which frequencies increase in amplitude?
  - With gearbox wear?
  - With torque / rotation speed / transiently?
  - Resonance?

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