Note Title 5/10/2018

Module 4
Lecture 9

SHM - AMS - TLP

- IV

Data acquired < wired / wireless | need to be checked for user reliability

Reliability formulations — statistical tools to assess the data

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- Statistics of the acquired time history responses
  - responses: surge, heave, pitch
    - wired
    - wireless: sym-I, II
- Quantify them by their probability distributions
- some level of uncertainty is
  - ↓ type of distribution
  - ↓ Exact shape for comparison
- distribution does not fit with that of the acquired data, reliability estimates can become inaccurate
- Best fit is required to be established

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- Distribution analysis should be carried out
- probability plots are used for comparing the distribution
- Goodness of fit test measures the compatibility of the random sample with the pdf distribution
- chi-square test

$$\chi^2 = \sum_{i=1}^{k} \frac{(O_i - E_i)^2}{E_i} \quad \text{---} \quad (1)$$

O_i - observed frequency for its bin

E_i - corresponding expected freq.

$$E_i = F(x_u) - F(x_l) \quad \text{---} \quad (2)$$

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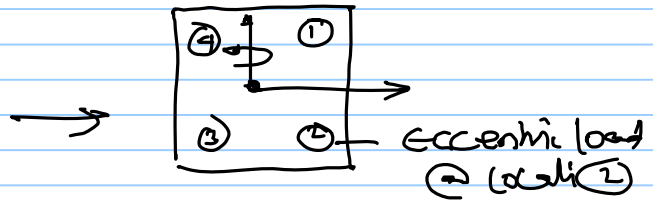
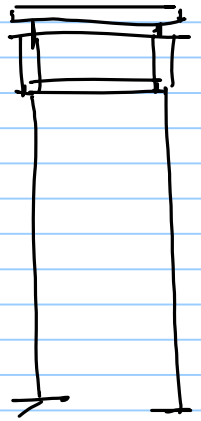
F is the CDF of the probability distribution which is being tested ($x_1, x_2 \cdots x_i$ - limits of the i^{th} bin.

Tabulate postulated failure cases - Degrees-of-freedom
- distribution. - parameters.
- prob of exceedance //

Postulated Failure case	DOF	Distribution	Parameters	Prob of Exceedance (%)
Case 1	Surge	Cauchy	μ = -0.0109 σ = 0.0642	4.22
	Pitch	Cauchy	μ = 0.0234 σ = 0.3702	7.41
	Heave	Dagum (4p)	α = 15.382 β = 0.4326 γ = - 0.3340 k = 0.303	40.07
Case 2	Surge	Cauchy	μ = 0.0181 σ = 0.0801	5.58
	Pitch	Cauchy	μ = 0.3445 σ = 0.5010	12.22
	Heave	Gen Extreme Value	μ = -0.0147 σ = 0.0266 k = -0/1546	2.68
Case 3	Surge	Cauchy	μ = -0.0133 σ = 0.0772	5.03
	Pitch	Cauchy	μ = 0.0106 σ = 0.1131	2.28
	Heave	Log Logistic	α = 14.006 β = 0.4893 γ = -0.4861	18.13
Case 4	Surge	Cauchy	μ = -0.0119 σ = 0.1027	6.63
	Pitch	Cauchy	μ = -0.0466 σ = 0.2173	4.21
	Heave	Cauchy	μ = 0.0159 σ = 0.0341	21.43
Case 5	Surge	Cauchy	μ = 0.0204 σ = 0.4765	25.91
	Pitch	Cauchy	μ = -0.0173 σ = 0.8381	15.34
	Heave	Dagum (4P)	α = 13.815 β = 0.4665 γ = -0.3864 k = 0.3380	30.3



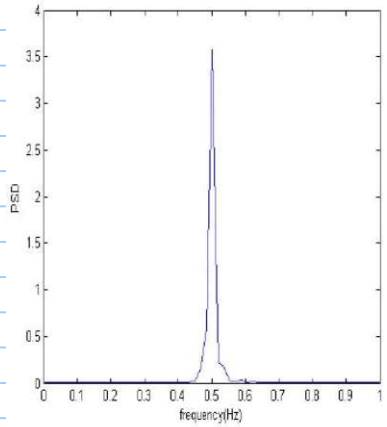


PSD are also plotted

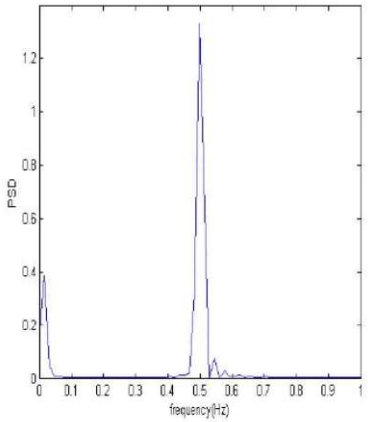
surge

heave responses for all possible failure cases.

pitch



(a)



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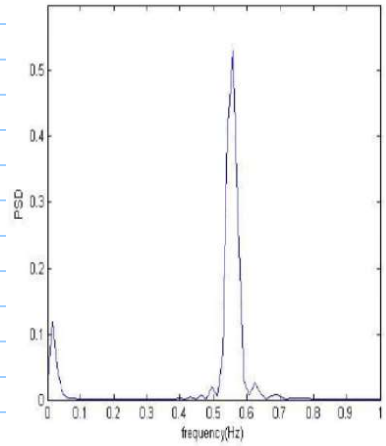

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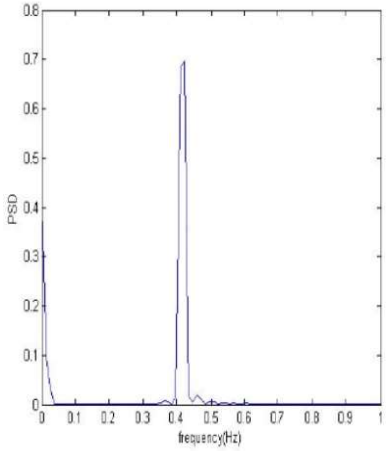
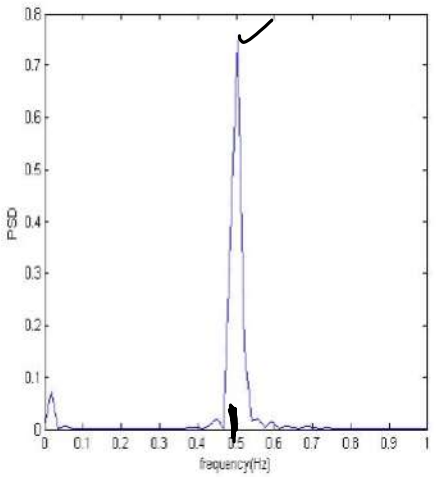


(d)

Surge response (PSD) (postulated failure case 4)

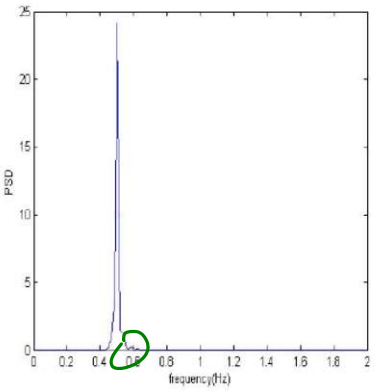


(e)

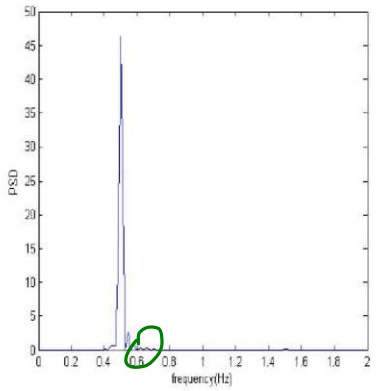
- peak surge response occurs @ frequency
  - insignificant variation compared with the normal case.

- a smaller peak seen @ 0.5Hz
  - second order vibrations caused by the failure frequency (0.5Hz)
- postulated damage identifier (frequency @ lower value)
  - not seen in the normal case
- Identifier of damage

SHM design — extracted feature extraction



(a)



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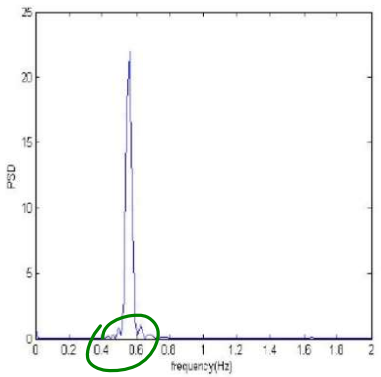

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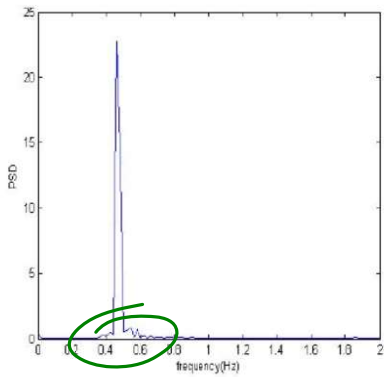


(d)

pitch-response (failure case 3)

damage case - normal case - marginal variation in the amplitude

- sensors are able to record/acquire the data accurately

(WSN)

— wired sensor — base data

- additional small peaks - may be due to noise

- from the postulated damage scenario,

- extract global features

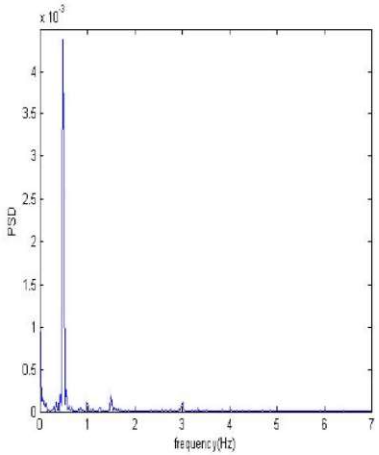
- but no localization in time-domain

Need to perform STFT for hamming window.
to catch/register localised fault damage

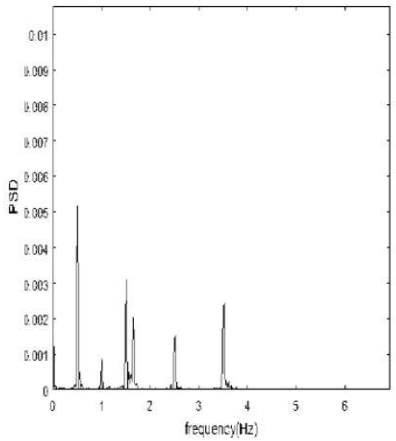
STFT plot for surge response

3d graph.

surge response { normal, postulated fault } are shown



(a)



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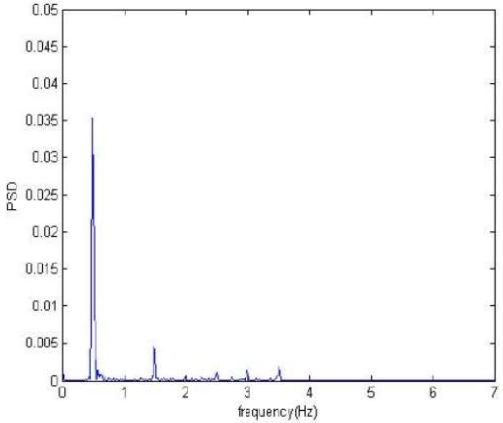

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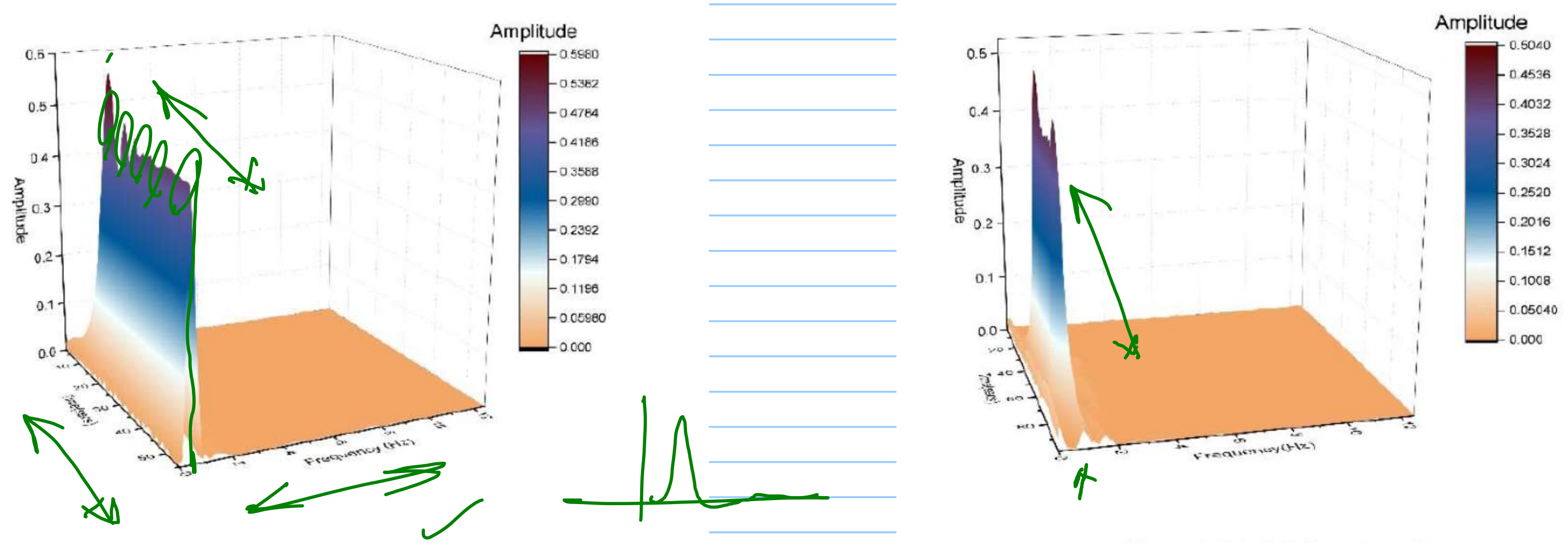
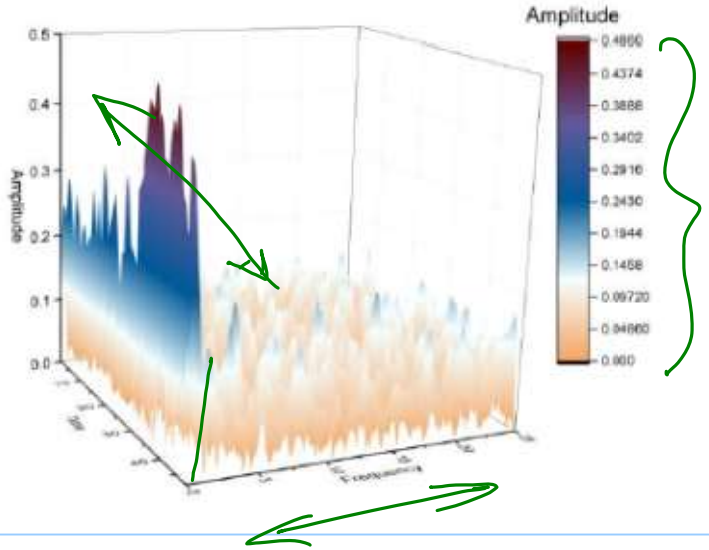


(a) **normal case** (b) **postulated failure (case2)**

Surge response (STFT)

- wide range of frequency variation, occurring through the time history are successfully capture
- useful in diagnosing condition of the platform.



pitch response (failure ④)

Next task - inform client about the damage

SHM - Capture the damage
- damage identification - FFT
- damage - localization - STFT !!

→ Alert Monitoring system (AMS)

Data, acquired by the sensors, transmitted to the base station.
- stored in MySQL Database.

- Acquired data is processed for viewing it as a report
- actual response will be compared with the (pre-set) threshold value

Threshold value — mean amplitude of vibration undamaged scenario

In the real time monitoring

- Output of sensor nodes will be integrated with the data base
- Location (physical), where damage has occurred

✓ sensor node - ① — log ① — log ① is damaged !!

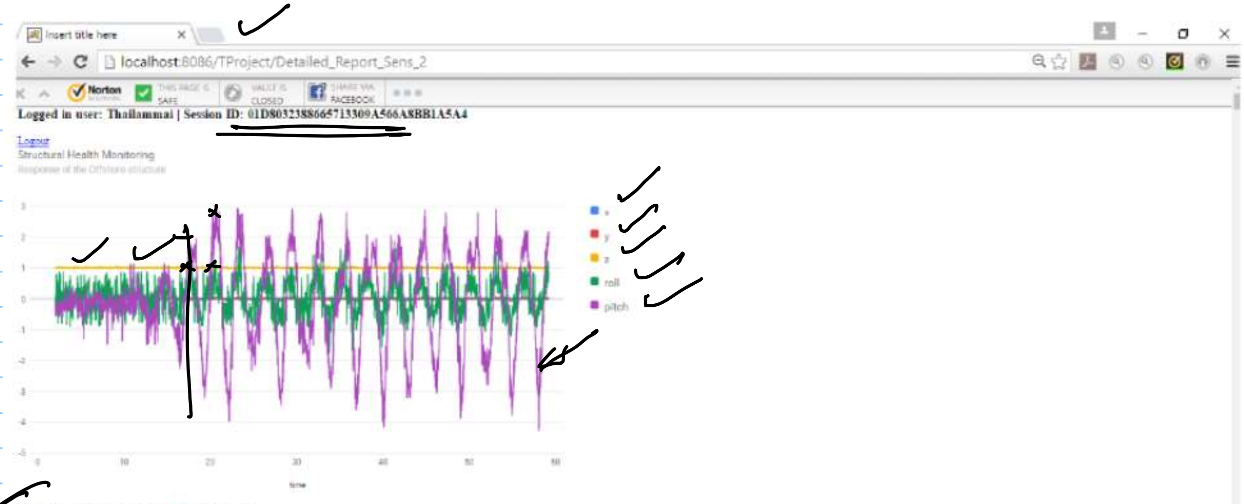
After processing the data,

central server will initiate SMS to registered mobile number (RMN)

on exceedance of the threshold value

With the SMS-API, SMS is triggered from the website

for ② factor authorization



Detailed Report for all Horizontal

ID	Date - Time	Time	X	Y	Z	Roll	Pitch
1	2016-01-09 22:10:29.327043	2.0058	0.0049	-0.0098	0.9934	-0.2818	-0.5670
2	2016-01-09 22:10:29.347144	2.0259	-0.0017	-0.0030	1.0012	0.0978	-0.1712
3	2016-01-09 22:10:29.364900	2.0437	0.0059	-0.0076	0.9986	-0.3364	-0.4380
4	2016-01-09 22:10:29.381968	2.0608	-0.0010	-0.0045	0.9912	0.0565	-0.2577
5	2016-01-09 22:10:29.398898	2.0777	0.0010	-0.0035	0.9981	-0.0561	-0.1998
6	2016-01-09 22:10:29.415825	2.0946	-0.0015	-0.0101	0.9959	0.0843	-0.5797
7	2016-01-09 22:10:29.432691	2.1115	-0.0139	-0.0049	1.0012	0.7967	-0.2830

SMS || message log(1) has failed

email

↓

repeat

SHM-II — WSN

AMS

Summary

SHM – lab scale
- wired
- wireless

- specification of sensor
  processing unit
  transmission protocol

Data analysis
- FFT
- STFT

|| post-processing

threshold – undamaged state

AMS – SMS alarm
email alert

|| user – location
– Quantity
||