Structural Health Monitoring (SHM)
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Lecture - 80
Part - 2: Structural Health Monitoring (SHM) of lab scale model of TLP - III

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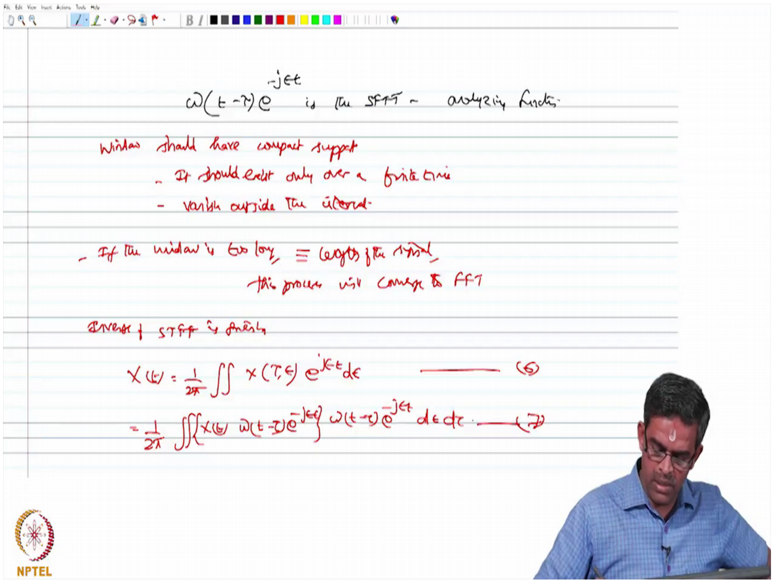

Now, omega of t minus tau epsilon minus j epsilon t is actually the short term Fourier transform or what we call in this present case as analyzing function. The window should have a compact support which means that it should exist only over a finite time and it should vanish outside this interval. Now, the window is too long and even e equal to the length of the signal then in that case this process will converge to a conventional fast Fourier transform.

Inverse of STFT is given by X of t 1 by 2 pi double integral X of tau epsilon e j epsilon t d epsilon which can be expanded as 1 by 2 pi double integral X of t omega t minus tau e minus j epsilon t omega t minus tau e to the power of minus j epsilon t d epsilon d tau. Let us call this as equation number 6, this as the equation number 7.

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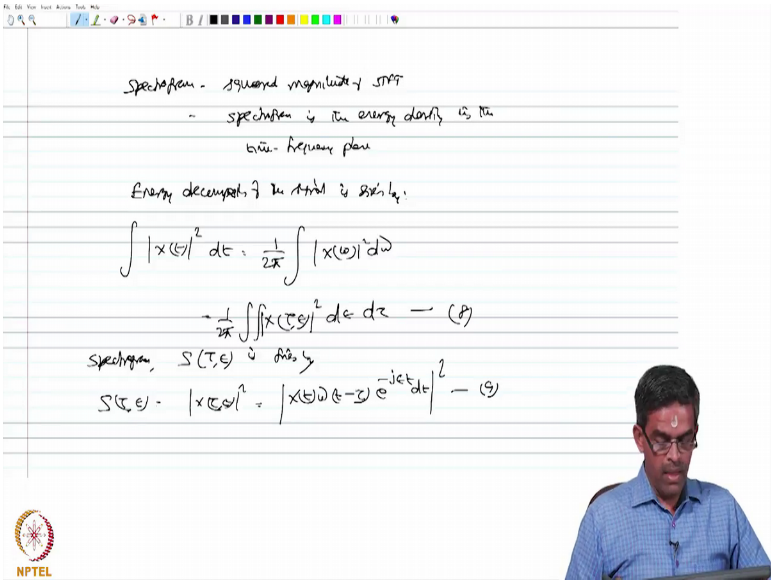

The spectrogram what you plot is actually the squared magnitude of short term Fourier transform. Now, spectrogram is the energy density in the time, frequency, plain. Energy decomposition of this signal is given by integral X of tau dt is one by 2 pi integral mod value of X of omega squared d omega which is 1 by 2 pi double integral X of tau epsilon square d epsilon d tau, equation number 8. S of tau epsilon is given by S of tau epsilon is mod value of tau epsilon squared which is actually equal to X of t omega of t minus tau e minus j epsilon t dt for the whole square.

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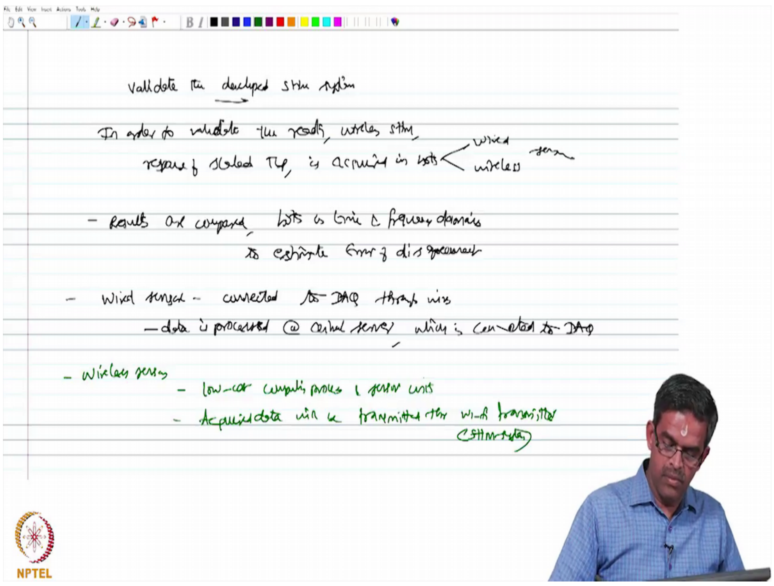

So, now friends the study has been conducted using two cases; one is a wired sensor, other is the wireless sensor network developed for SHM. Now, there is very important thing we need to validate the developed structural health monitoring system, is it not? Let us validate this. In order to validate the readings taken by wireless structural health monitoring response of this scaled TLP, is acquired in both wired and wireless sensors.

Now, the results are compared both in time and frequency domain to estimate the error of disagreement, so that the designed SHM can be qualified let us reiterate one important statement wired sensors are connected to the DAQ data acquisition system through wires. The data is processed not at the sensor level, but at central server which is connected to the DAQ that is the data acquisition system. On the other hand, we talk about wireless sensors. They comprise of low cost computing processor and sensor units. Now, the acquired data will be transmitted through transmitter which is connected in the SHM system.

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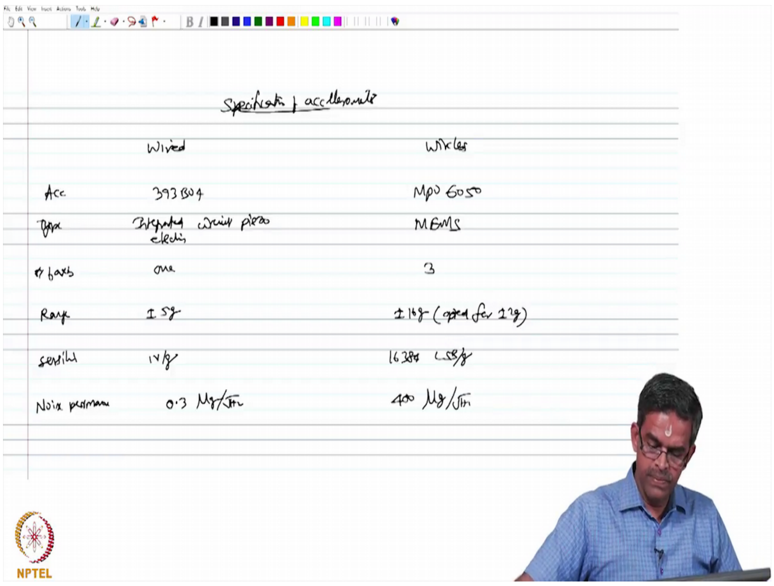

Let us talk about accelerometer for the wired and for the wireless. The accelerometer used is 393 B04; in this case it is an integral unit of MPO 6050. The type is integrated circuit of piezoelectric, in the case of wired sensors. In the case of wireless they are MEMS type sensors. The number of axis which wired sensor can measure is one, whereas we have tri axial capability. The range is plus minus 5g whereas, this is plus minus 16g, but opted for plus minus 2g only, ok. Sensitivity this is 1 volt per gram this is

16384 LSB per gram; the noise performance, 0.3 by root hertz, whereas in this case it is 400 mu g per root hertz.

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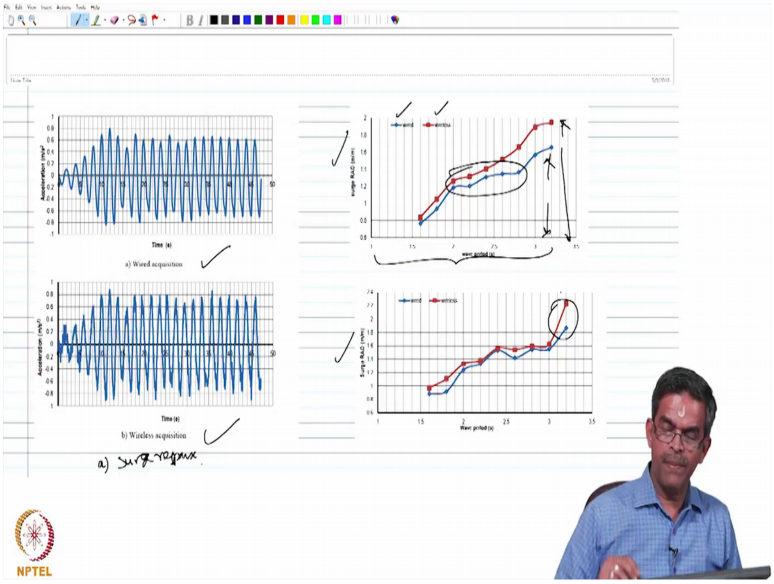

Let us see the comparison between the data acquired between the wired and wireless sensors. The data what you see here is an wired acquisition and the data shown below is in wireless acquisition. Both of them are obtained for the surge response. If you look at the response amplitude operator value for such the blue one indicates the wired sensor data and the red one indicates the wireless. You can see here the trend of acquiring data over a large period during experimentation is more or less the trend is qualitatively matching except that there is a variation in the response compared to that of the wire one. Qualitatively, they are more or less matching except the justification for these gaps which are miss agreement.

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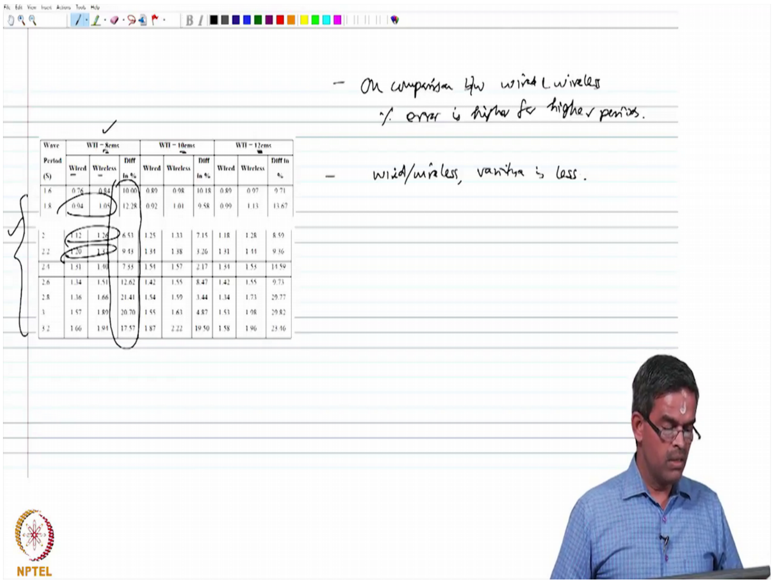

The values are also tabulated for different wave height or different wave periods both wired and wireless with the percentage difference as you see here. So, the periods have varied anywhere from 1.6 to 3.2 with a constant interval and the wave height is also changed in terms of 8 centimeter, 10 and 12 centimeters. So, one can see here on comparison of the data between wired and wireless percentage error is higher for higher periods. If you look at the variation look at the variation between the wired and wireless, the variation is very less.

So, this shows a partial validation of the SHM design using wireless sensor networking which is being carried out in the present study.

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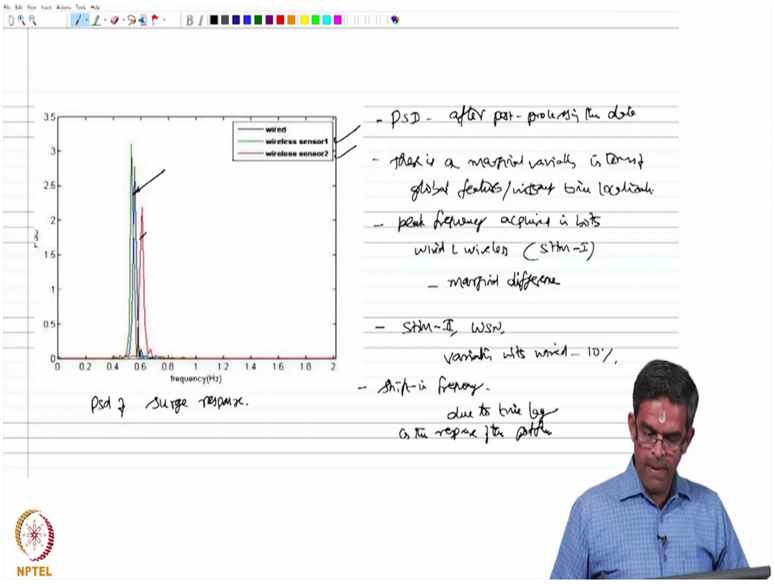

One cannot so plot this variation in frequency domain and now, comparing both the sensor units wireless sensor 1 and 2 which we already discussed in the earlier lecture the variation is on the MBU 6050 module of the sensor. So, the wire one is shown in the blue color, the green one indicates the sensor one wireless sensor networking 1 type 1 and the red one type 2. The power spectral density function for surge response is obtained after post processing the data. One can see here there is a marginal variation in terms of global features without time localization.

The peak frequency in both the cases the peak frequency acquired in both wired and wireless that is let us say wireless there is SHM – I. They have a very marginal difference when I use SHM design II for wireless sensor networking and compare that with the wired sensor then the variation with wired sensor is about 10 percent. There is a shift in the frequency also, this may be due to the time lag in the response of the platform. When we look at the comparison we saw that the agreement is very close.

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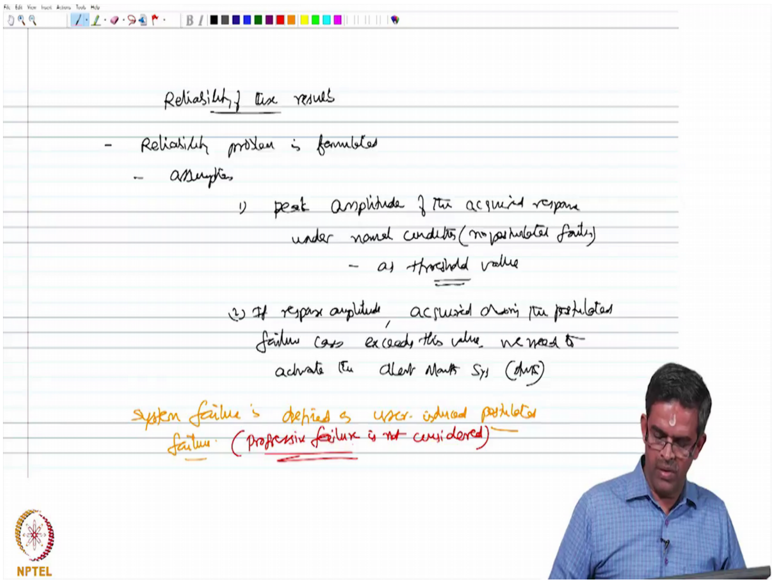

After realizing this we need to estimate the reliability of the results, because we have got now the results both the sensor models. What is the reliability of these results? So, reliability problem is formulated. There are some assumptions that we made in doing this. The peak amplitude of the acquired response under normal conditions that is no postulated failure, all these are normal conditions now, no postulated failure is taken as the threshold value. This value will be now compared for damage index. Now, if the response amplitude increases which is acquired during the postulated cases exceeds this value then we need to activate the alert monitoring system, ok, that is the idea.

So, now, very clearly friends the system failure is defined as user induced postulated failure. We are trying to identify the sensitivity of the alert monitoring system which is going to become compatible with this postulated failure case. So, we are checking the reverse problem. AMS will trigger when damage occurs. What we are trying to do is, we create the damage and check, is AMS triggering or not? That is idea what we are doing, very important. The progressive failure is not considered only the damage indication of initiation of failure is considered not the progressive failure, ok.

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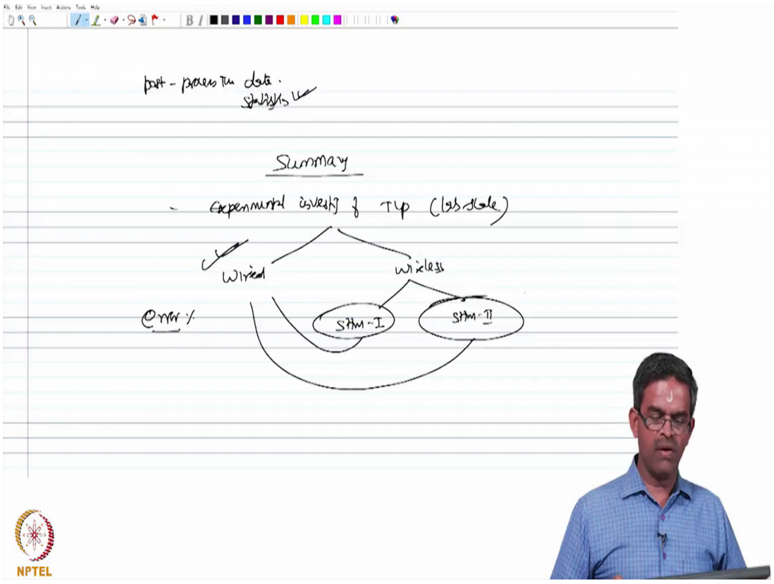

So, now, to understand this we have to post process the data one can use statistics to do this. Let us try to see how we can use statistical tools to compare this and then talk about the post related failure cases and check the alert monitoring system design is compatible or not.

So, friends in this lecture we discussed about the experimental investigation of tensile like platform on the lab scale model. The acquisition was done by both the sensor designs wired and wireless. Even wireless we had two designs SHM system one and health monitoring system two, where the sensor specifications are different. We are comparing both of them individually with the wired sensors and finding out the error percentage and checking this as the base, we are doing this. Ultimately, we are also trying to do a statistical analysis to check, so that we need to form a reliability problem and try to see what is the data we acquired the reliability of this data, so that one can be with the level of confidence commit the design will work both in the lab scale as well as on real time monitoring.

So, we will discuss about the further processing of the data using statistical tools and then the postulated failure cases in the coming lecture number 4.

Thank you very much.