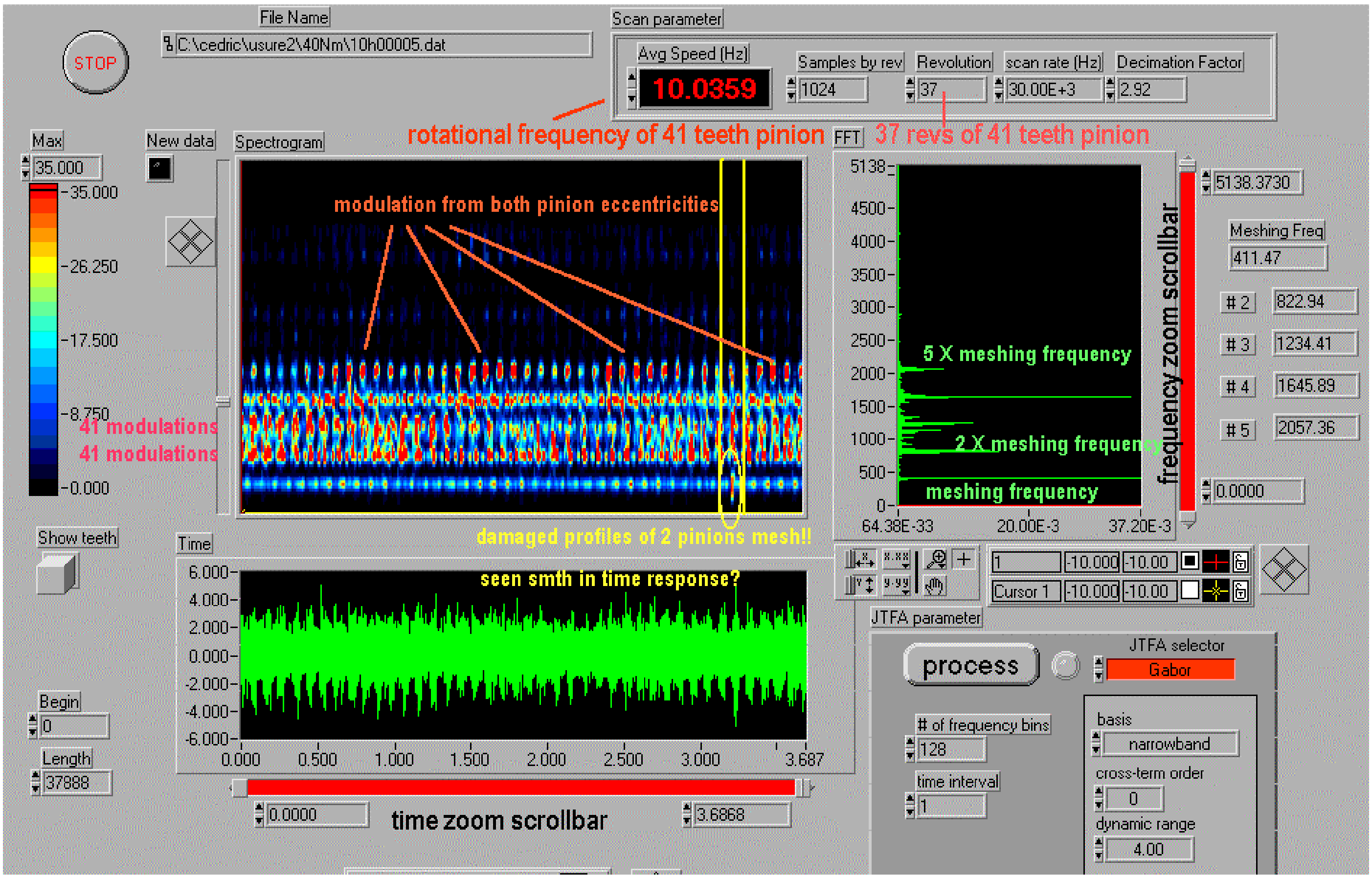
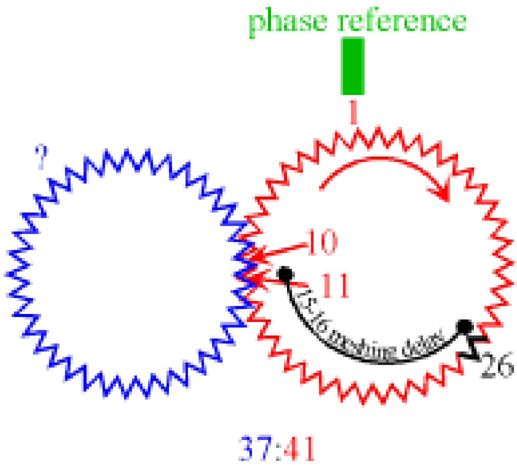
JTFA analysis of a gear drive with local wear on tooth profiles on both pinions.

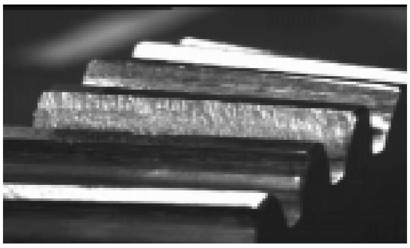


JTFA analyzing the accelerometric responses of a gear train damaged as shown in row below. Meshing frequency for the 41 teeth pinion rotating at ca 10.04 Hz is the first peak at 411.47 Hz in the Fourier analysis between 0 and 5138 Hz. Its higher harmonics are also present depending on the bearing frequency response. Not much can be ascertained either from the frequency or from the time domain responses (seen smth in time domain?).

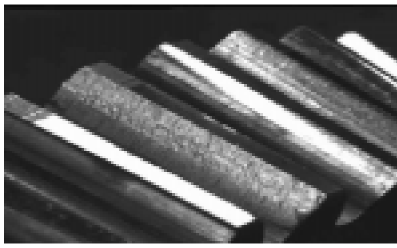
In the time-frequency Gabor spectrogram obtained with Labview toolkit, one can see a lot more:

Eccentricities of the small pinion: 41 clusters in the spectrogram at double and triple the meshing frequency. The small pinion indeed rotates 41 revs for 37 revs of the big one	**4 clusters in the spectrogram at 5 times the meshing frequency. They are caused by the modulation of the eccentricities of both pinions.**	**To top all this, see what happens at the meshing frequency! During the 32nd rev of the big pinion, one notices a hot spot in the spectrogram. This where the damaged profiles from both pinions mesh!**





Addendum wear on 26th and 27th tooth of 41 teeth pinion. Data acquisition starts when tooth 1 passes in front of the phase pickup. Teeth 10 and 11 are then meshing. Only after 15 to 16 meshing periods will the damaged profile come to mesh.

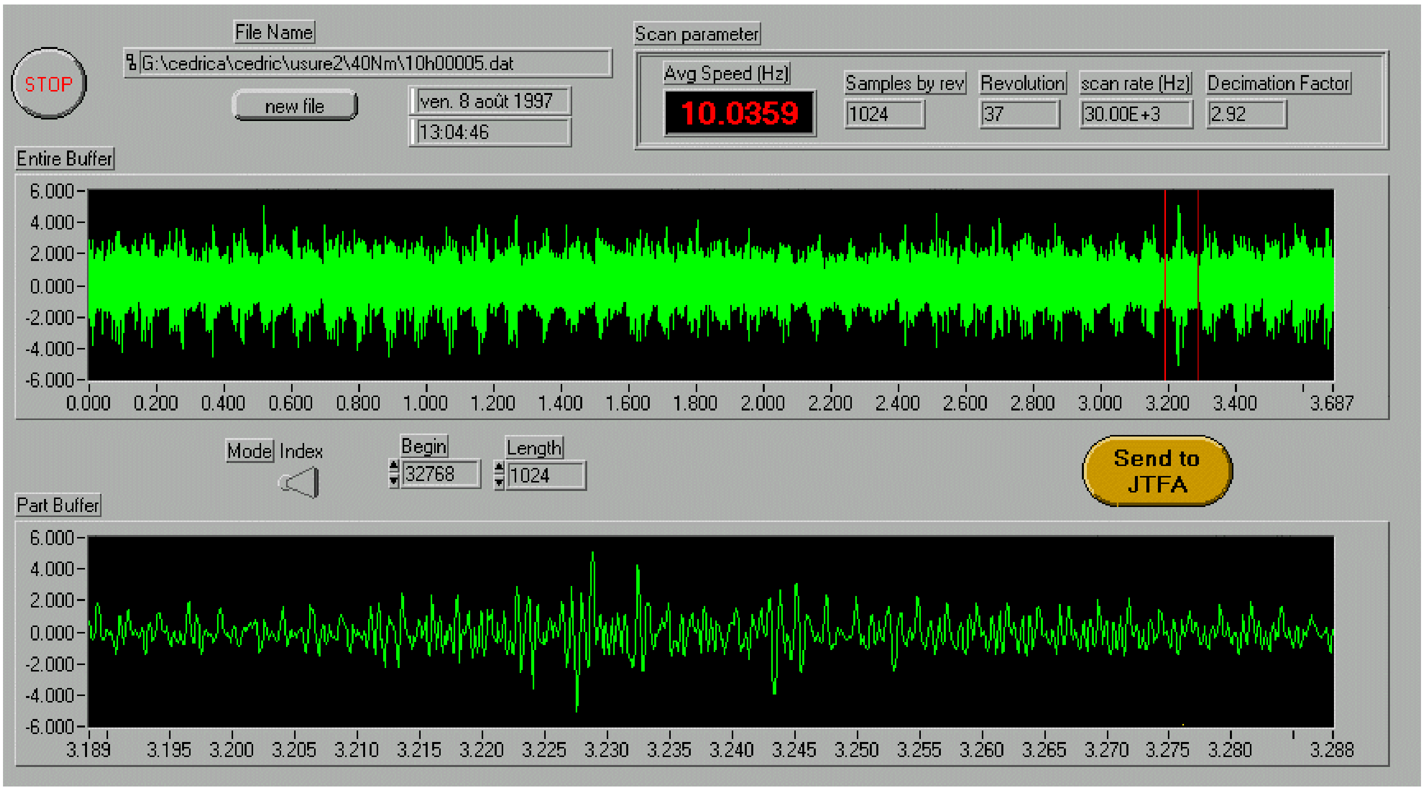


Full profile (addendum + dedendum) damage on the 37 teeth pinion. Position irrelevant (?) as long as data acquisition is not synchronized with two phase references, each one belonging to one of the pinions.

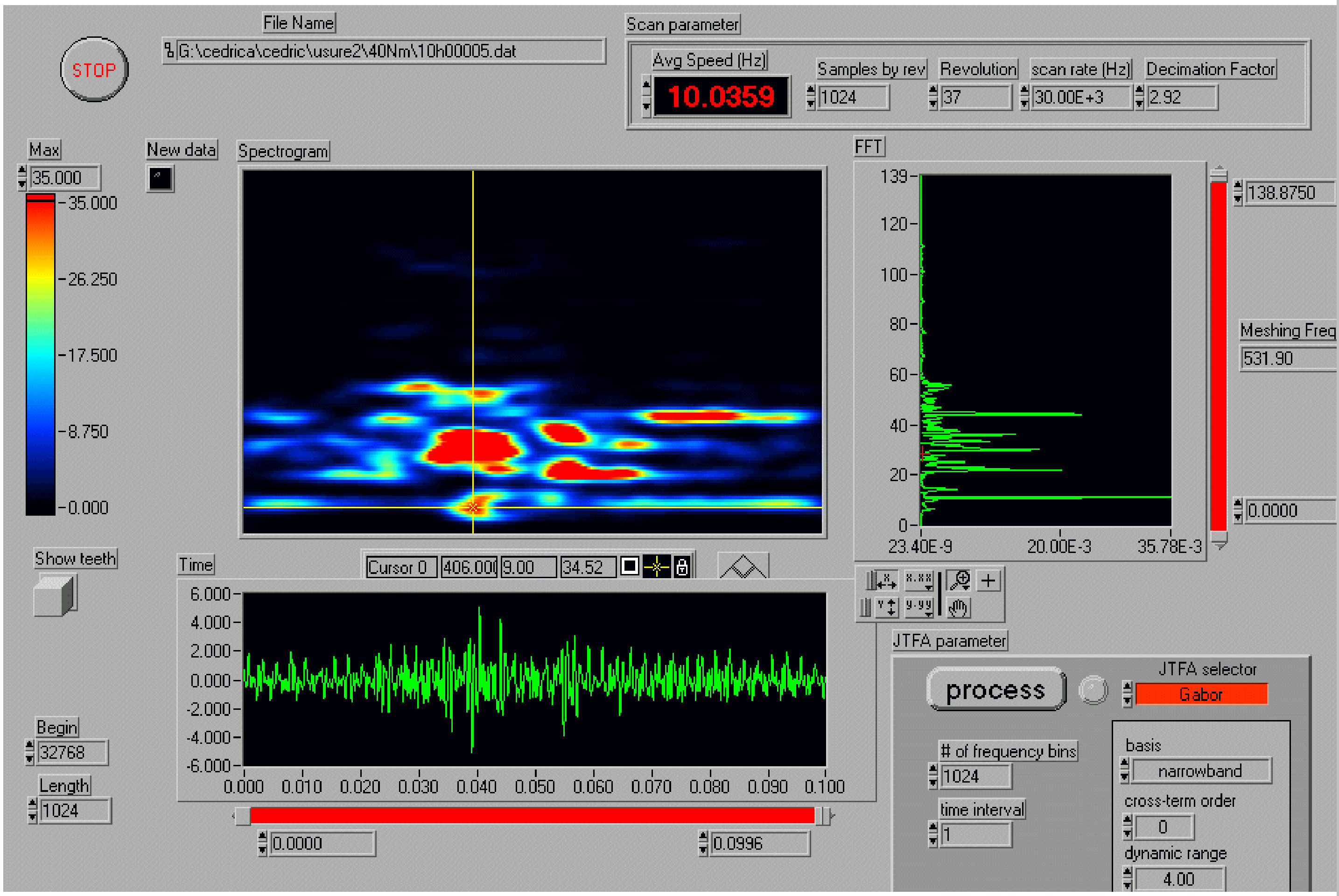
Now is the time to get a closer look at what happens during this 32nd rev of the big pinion. The shock should happen when the damaged profiles belonging to it mesh. From the above picture, this takes place when these profiles reach the position of teeth 10-11 at trigger time. Triggers time corresponds to tooth 1 being aligned with the phase reference that triggers the pickup that synchronizes the data acquisition at each rev (more on this in the section devoted to synchronous sampling). Thus at approximately 15.5/37 rev during this 32nd rev, the hot spot must appear. Since 1024 samples are acquired per rev (once again due to synchronous sampling), the hot spot should hover around the 429th sample.

Incidentally, one might ask the shock shows at the meshing frequency in the Gabor spectrogram. This is because two profiles are damaged on one pinion. With only one damaged profile, one would not excite the meshing frequency.

OK let us zoom the JTFA analysis on the 32nd rev.



Above is the time response of the accelerometer for 37 successive revs of the big pinion sampled 1024 times/rev. The cursor selects the 32nd rev whose zoomed time response is shown below. And now let us get the Gabor spectrogram for it.



The cursor is set at the 406th sample where the hot spot of the spectrogram shows up. That is quite close to the predicted 429th sample. Such a discrepancy is due to the contact ratio 1.648 and the fact that two successive profiles were damaged on the big pinion . One could argue that the time response over the 32nd rev could reveal the damage. That is unfair, because it also exhibits peaks elsewhere in the full 37 revs analysis. It is only after we zooming on the 32nd rev based on the spectrogram at the meshing frequency that one could claim that.

Although the time-domain accelerometer responses fail to spot any damage, the latter could yet be audible. Some other researchers also observed such a situation.

The literature often mentions the presence of frequency modulation in time-frequency analyses. This stems from varying rotational speeds. Synchronous sampling "kills" this modulation by sampling the responses at equal angular intervals of the pinion revolution. Thus the spectrograms shown here are related to order tracking. To be honest one should label frequencies in terms of orders and not in Hz in the above vi's. As long as the rotational speed does not vary much this remains acceptable. The only frequency modulation that might occur in this case of synchronous sampling would be traced to rapid rpm changes over one rev since the sampling rate re-synchronizes only once per rev in the vi, due to the fact it isn't always easy to fit incremental encoders in practice.