10 Hz deltas issue

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preliminary draft VIR-NOT-ROM-xxx

Analyzing the peak maps (peaks of the time-frequency sfdb spectra) of C6 and C7, it appears that, at frequencies multiples of 10 Hz, we have big excesses of peaks. The cause of this is the presence of 10 Hz trains of delta pulses.

PSS peak maps

In the search of periodic sources, done with the pss software, a basic task is the construction of the short FFT database (SFDB) and, from this, the peak maps, the collection of the peaks of the equalized periodograms above a given threshold (2.5). The peces on wich the FFT is done are interlaced and windowed.

Here are the basic parameters for the C6 and C7 runs (higher band)

	C6	C7
Sampling time	0.00025 s	0.00025 s
Length of FFT	4194304	4194304
FFT duration	1048.576 s	1048.576 s
Number of FFTs	2287	556
Frequency bin	0.000953 Hz	0.000953 Hz
SFDB - files	23	6
SFDB - GB	35.8	8.7
Peak map - files	4	1
Peak map - GB	3.67	0.88
Total number of peaks	~500 millions	~120 millions

The procedure of the construction of the SFDB and peak map is described in P.Astone et al. “The short FFT Data Base and the peak map for the hierarchical search of periodic sources”, in the Annecy GWDAW proceedings. The data used are the 4 kHz h-reconstructed.

This issue came out in the quality control of the C6 and C7 peak maps.

Preliminary analysis

The check of a peak map file is done by Matlab, with the use of the functions

- read_peakmap
- show_peaks
- ana_peakmap

Here is the analysis procedure call

>> [spfr,sptim,peakfr,peaktim,npeak]=ana_peakmap(0,0,0,0)

then choose interactively the vbl file containing the peak map.

Here is the ana_peakmap function:

```
[spfr,sptim,peakfr,peaktim,npeak,splr,peaklr]=ana_peakmap(frband,thr,
time,res,file)
%ANA_PEAKMAP  analyzes a vbl-file peakmap
%
%   frband           [min,max] frequency; =0 all
%   thr              [min,max] threshold (mjd); =0 all
%   time             [min,max] time (mjd); =0 all
%   res              resolution reduction in frequency in low-res
maps; =0 no low-res
%   file             input file
%
%   spfr,sptim       mean spectrum vs freq and time
%   peakfr,peaktim   number of peaks vs freq and time
%   splr,peaklr      t-f peak maxima and number
%   npeak            total number of peaks
```

Here are the basic results for C6 and C7

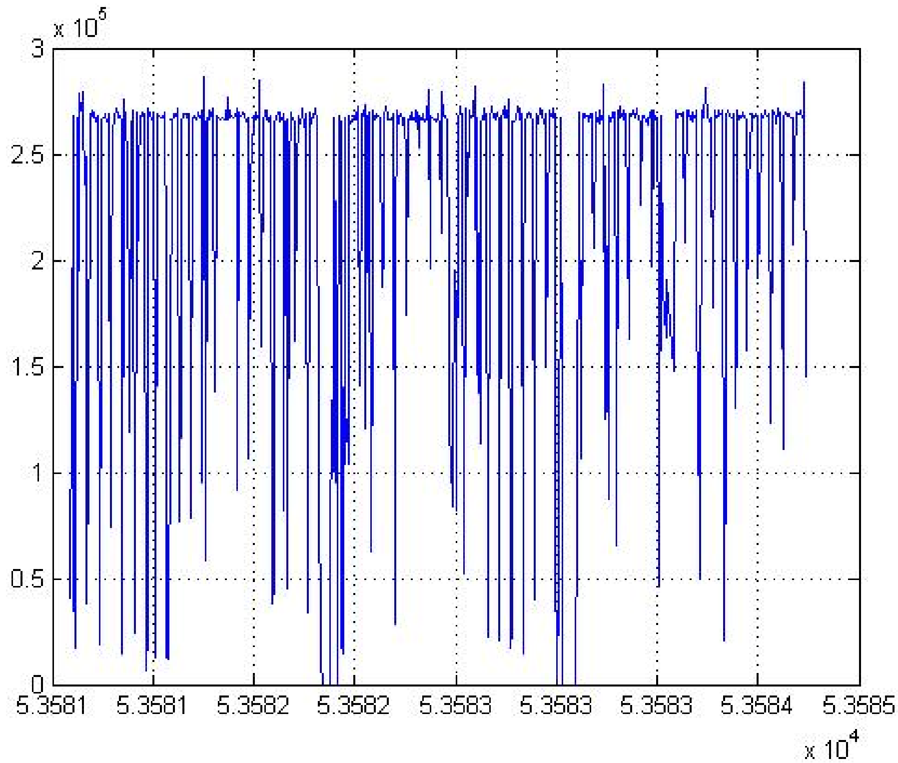
C6

- file peakmap-c6_1.vbl
- number of peaks 134,152,922

(there are 4 peakmap files, with similar results)

peaktim

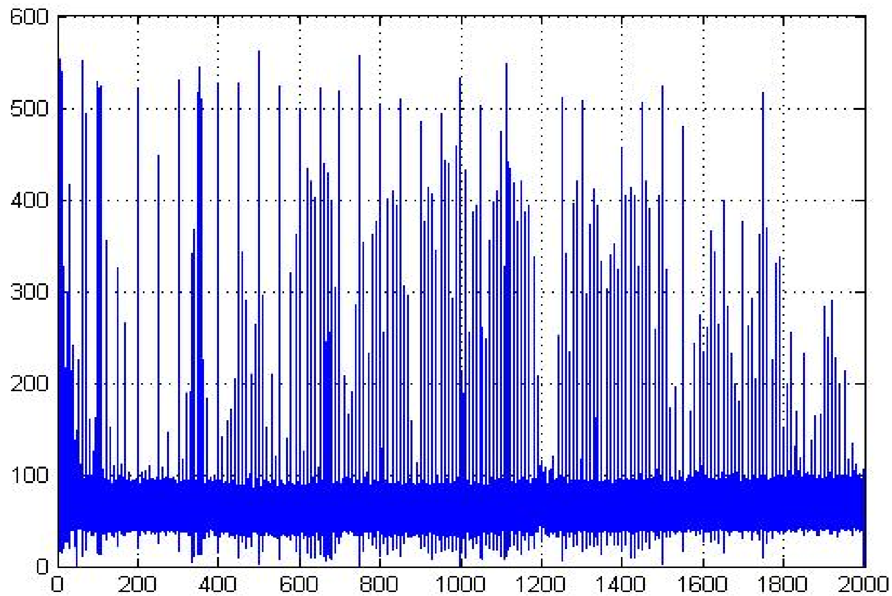
This is the number of peaks for each equalized periodogram. In abscissa there is the time of the FFTs (total about 4 days)



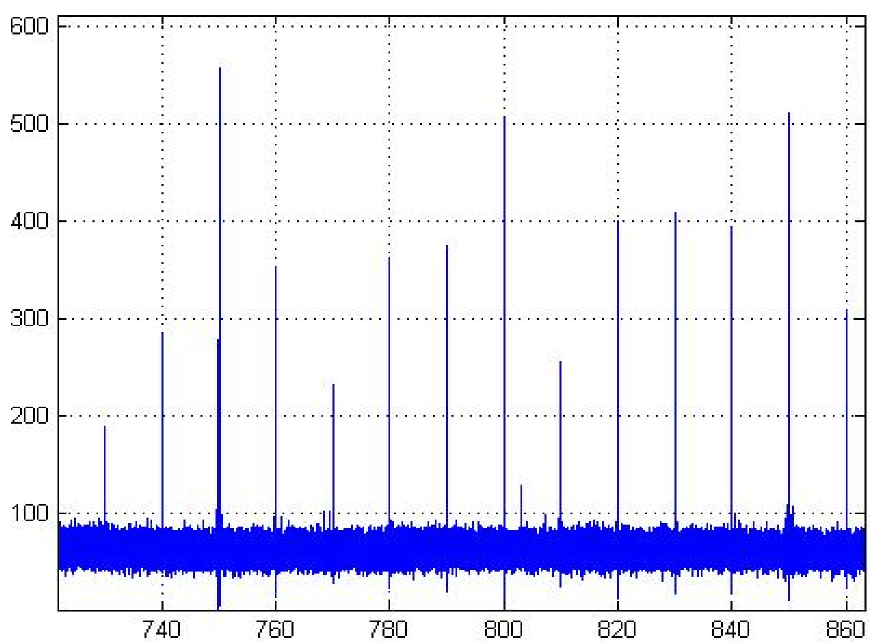
It appears that, except some ”disturbed” cases, the mean number of peaks for FFT is almost constant (~270000).

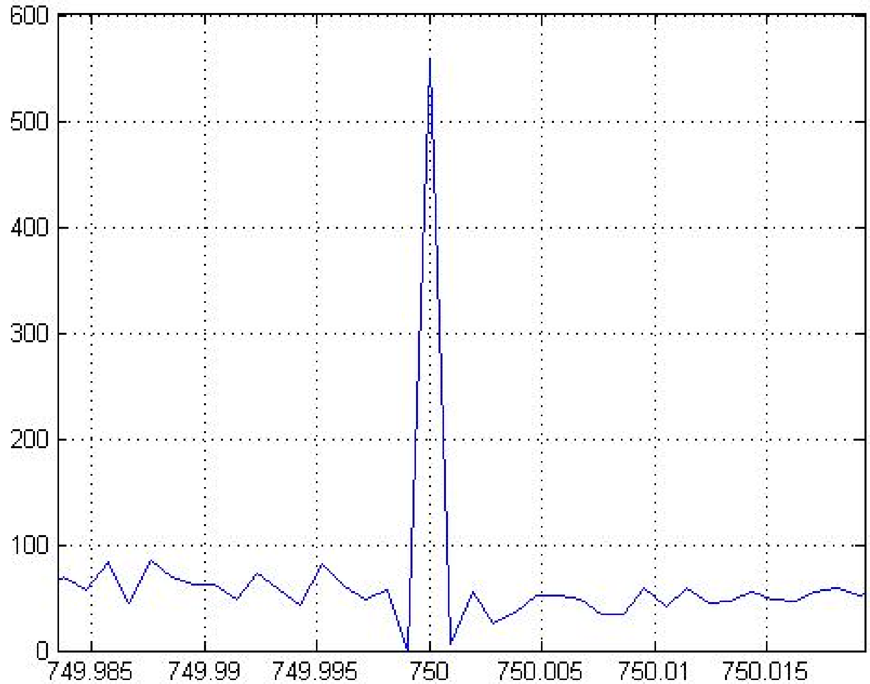
peakfr

Here is the number of peaks per frequency bin (that is about one mHz). We see the (expected) presence of strong peaks at the multiples of 50 Hz and the unexpected presence of strong peaks at multiples of 10 Hz.



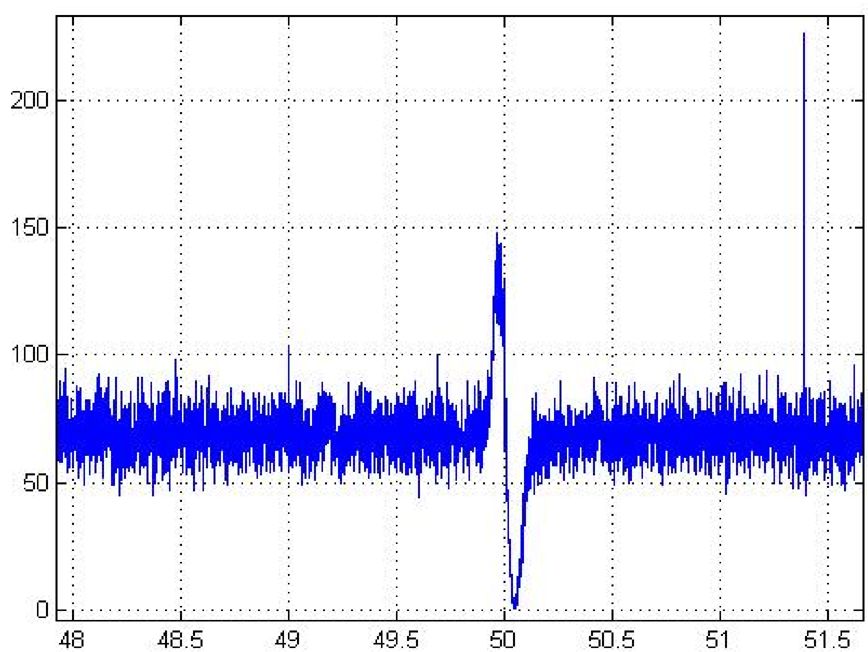
Here is some zoomed plots





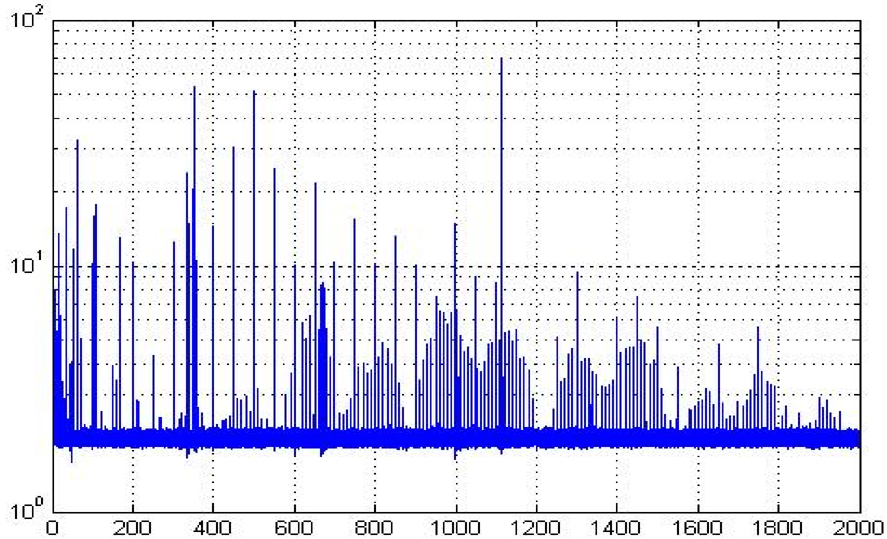
It appear puzzling the narrowness and precise frequency of the peaks. This indicates that a possible cause of this effect is the clock.

Here is the zoom of 50 Hz (that is “cut” by the equalizer procedure)



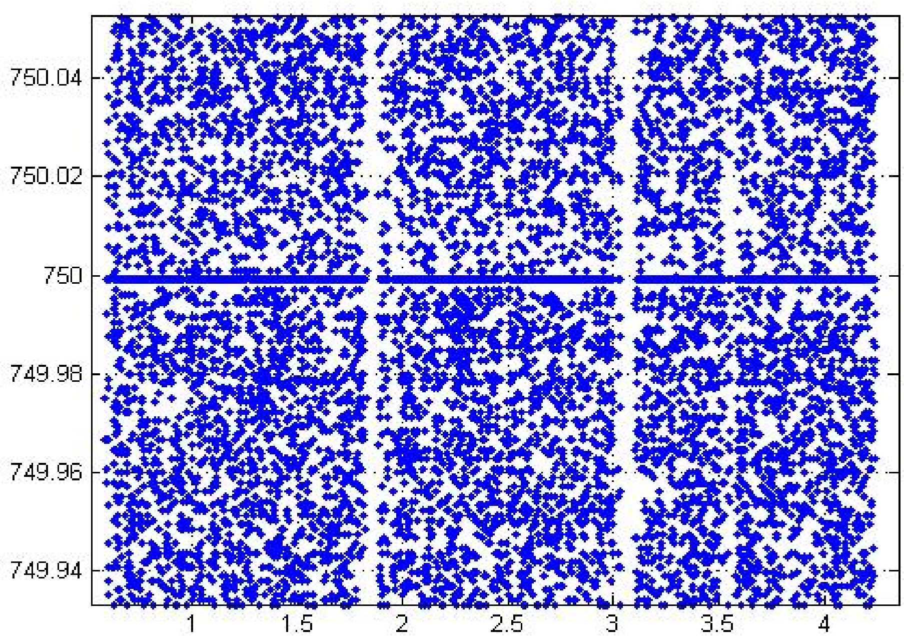
spfr

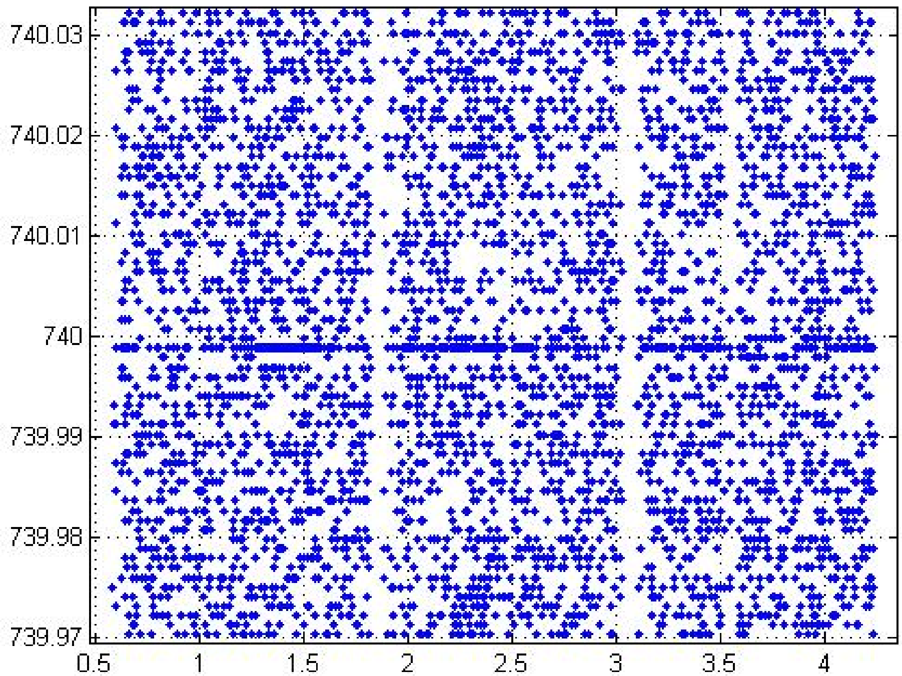
Here is the plot of the mean value of the peaks. Also on this plot (that is obviously independent by the preceding peakfr, there is the presence of the 50 Hz and 10 Hz effect.



time-frequency

Here are some sub-maps of the peak map. In abscissa there is time (in days) and in ordinate the frequency.

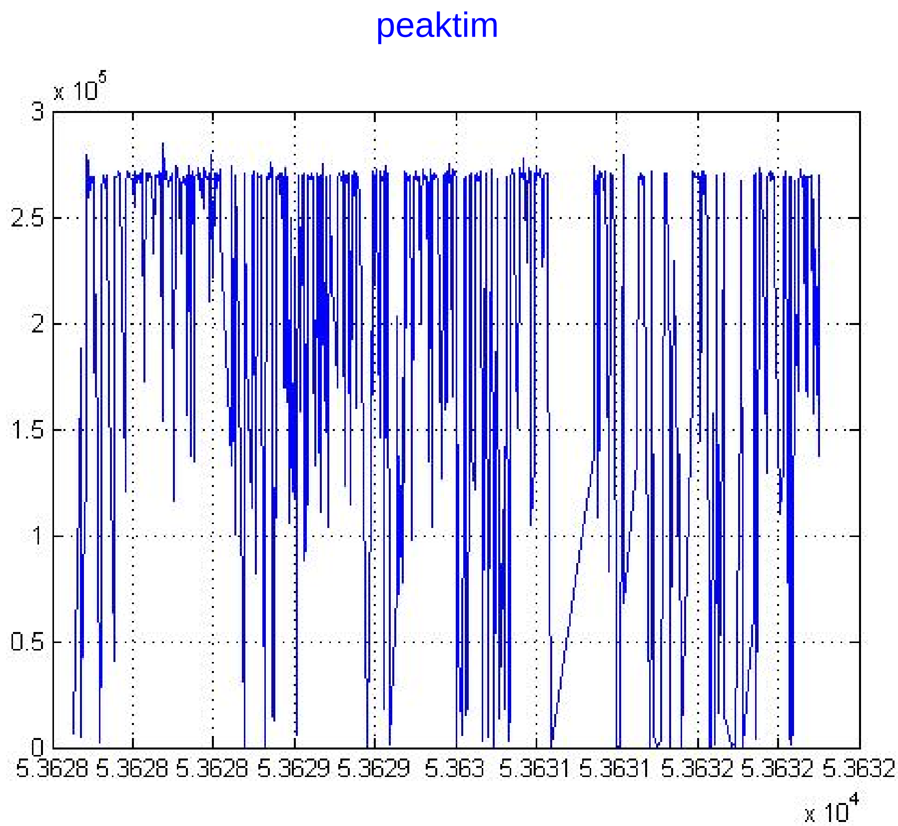



740.03
740.02
740.01
740
739.99
739.98
739.97
0.5
1
1.5
2
2.5
3
3.5
4

C7

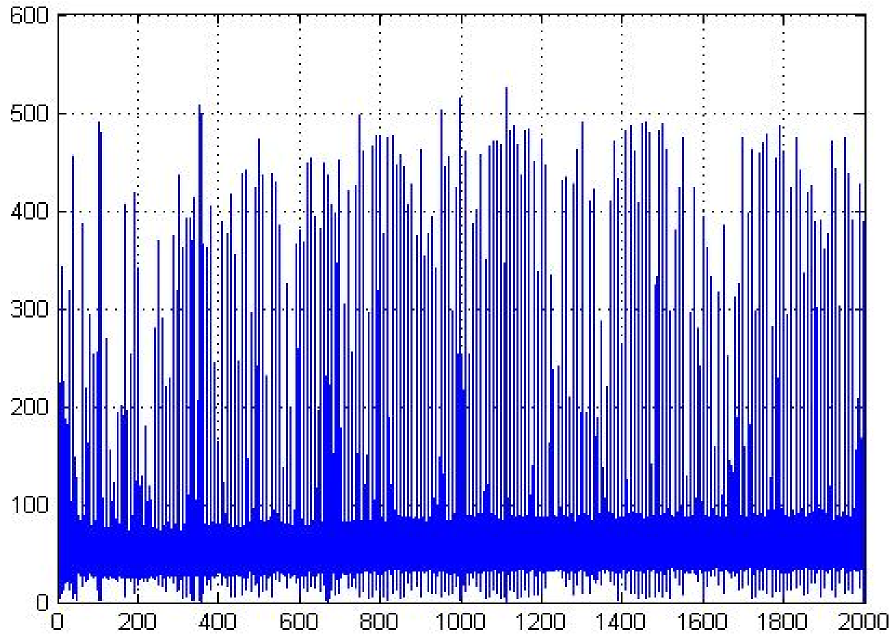
The same analysis is done for the C7 run.

- file: peakmap-c7.vbl
- number of peaks: 117,719,147



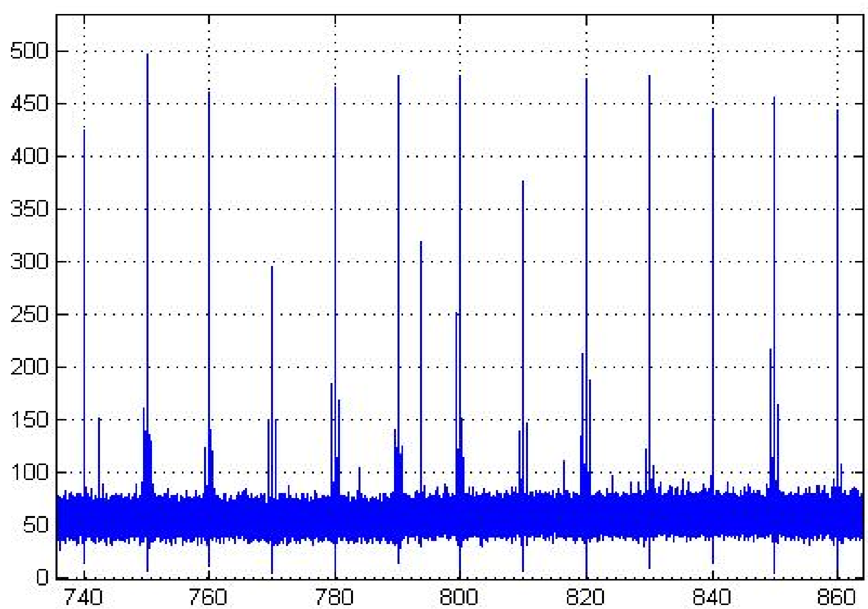
This plot is similar to that of C6.

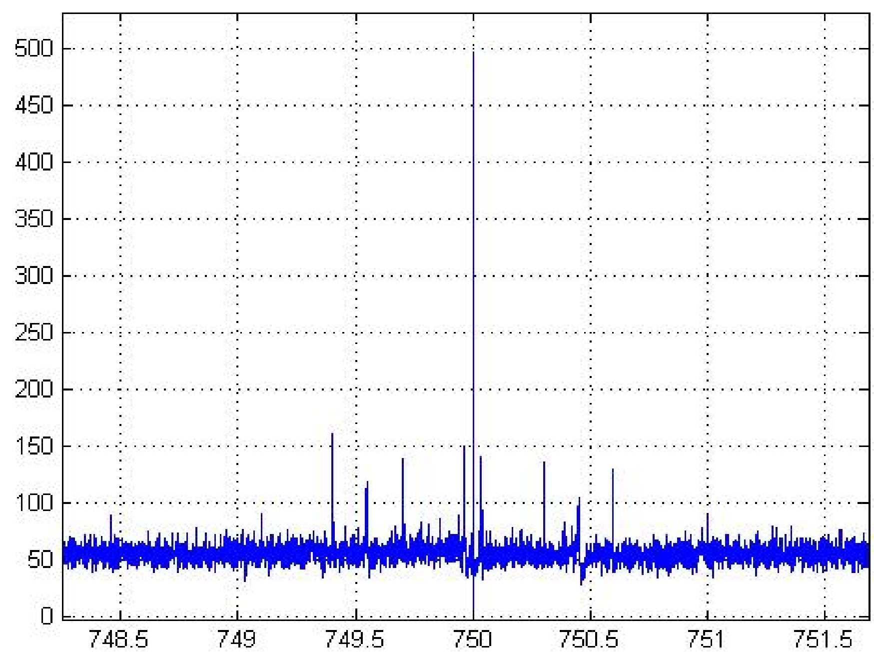
peakfr

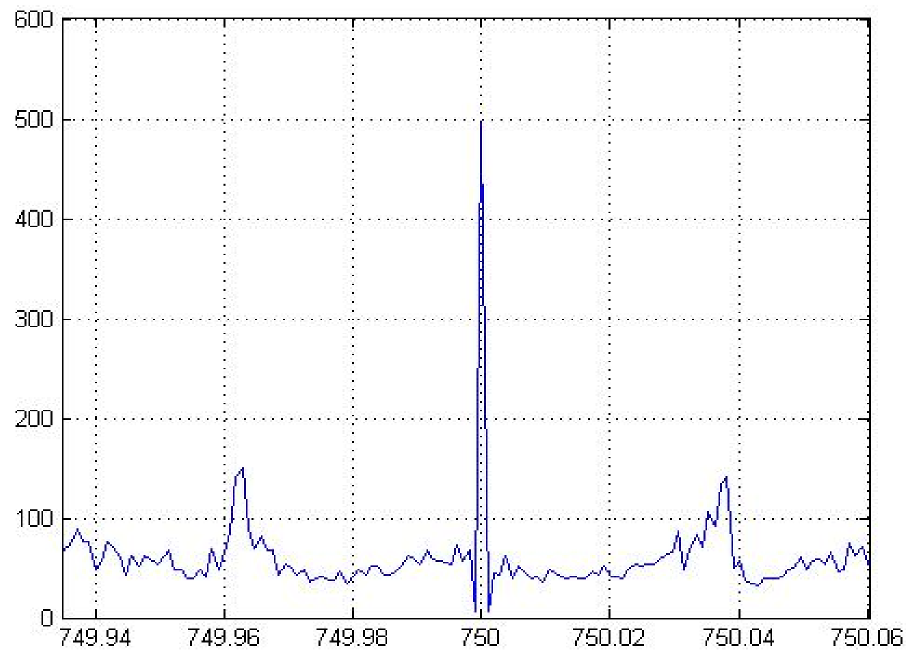


Here we see that the 10 Hz effect is stronger. Because at multiples of 50 Hz we have both the power line effect and the 10 Hz effect, we can conclude that the 10 Hz effect is much higher than the power line effect.

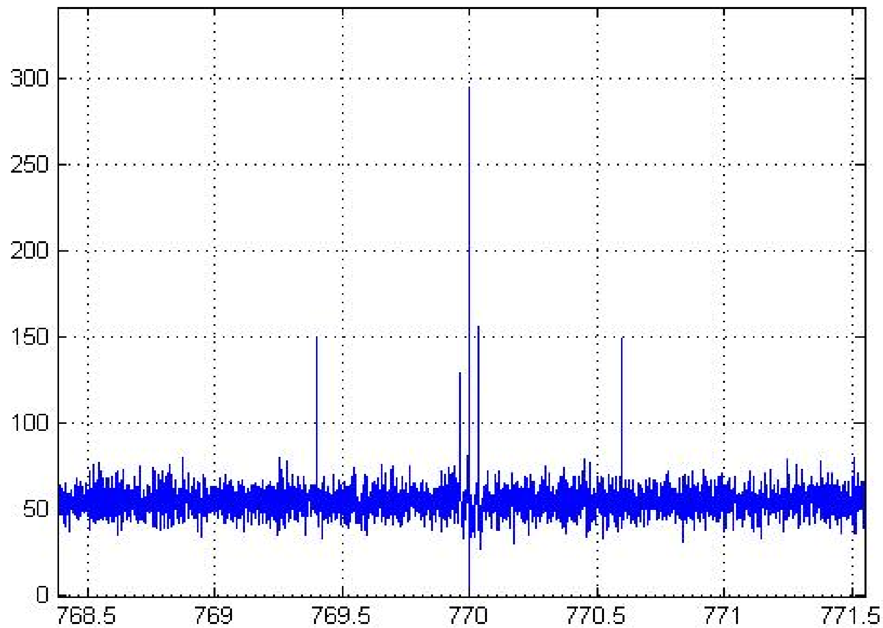
Here are some zoomed plots



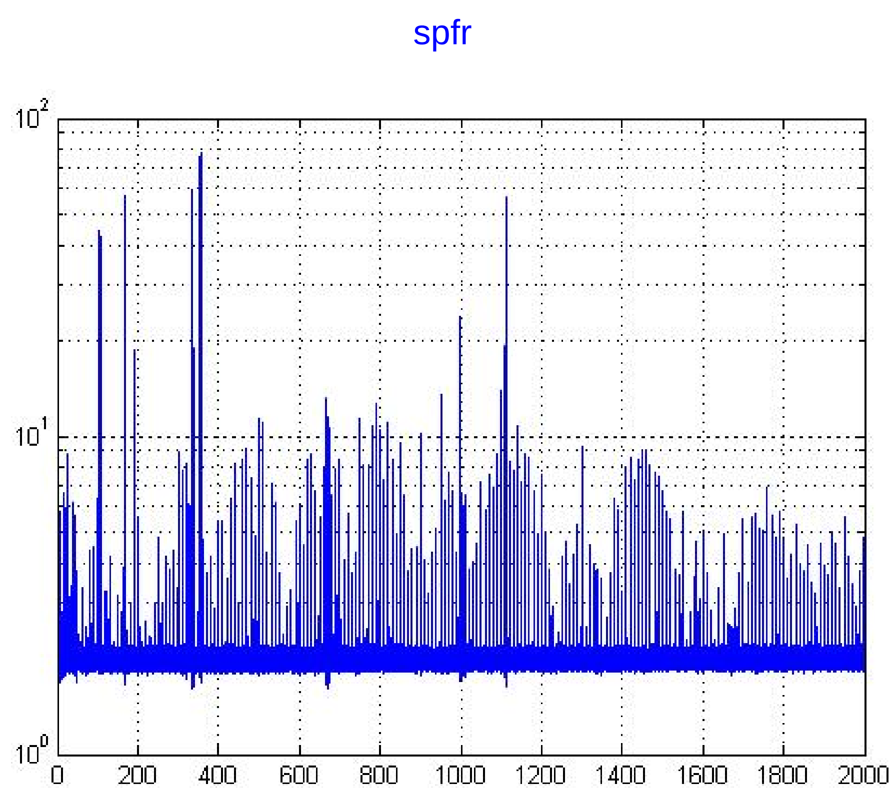




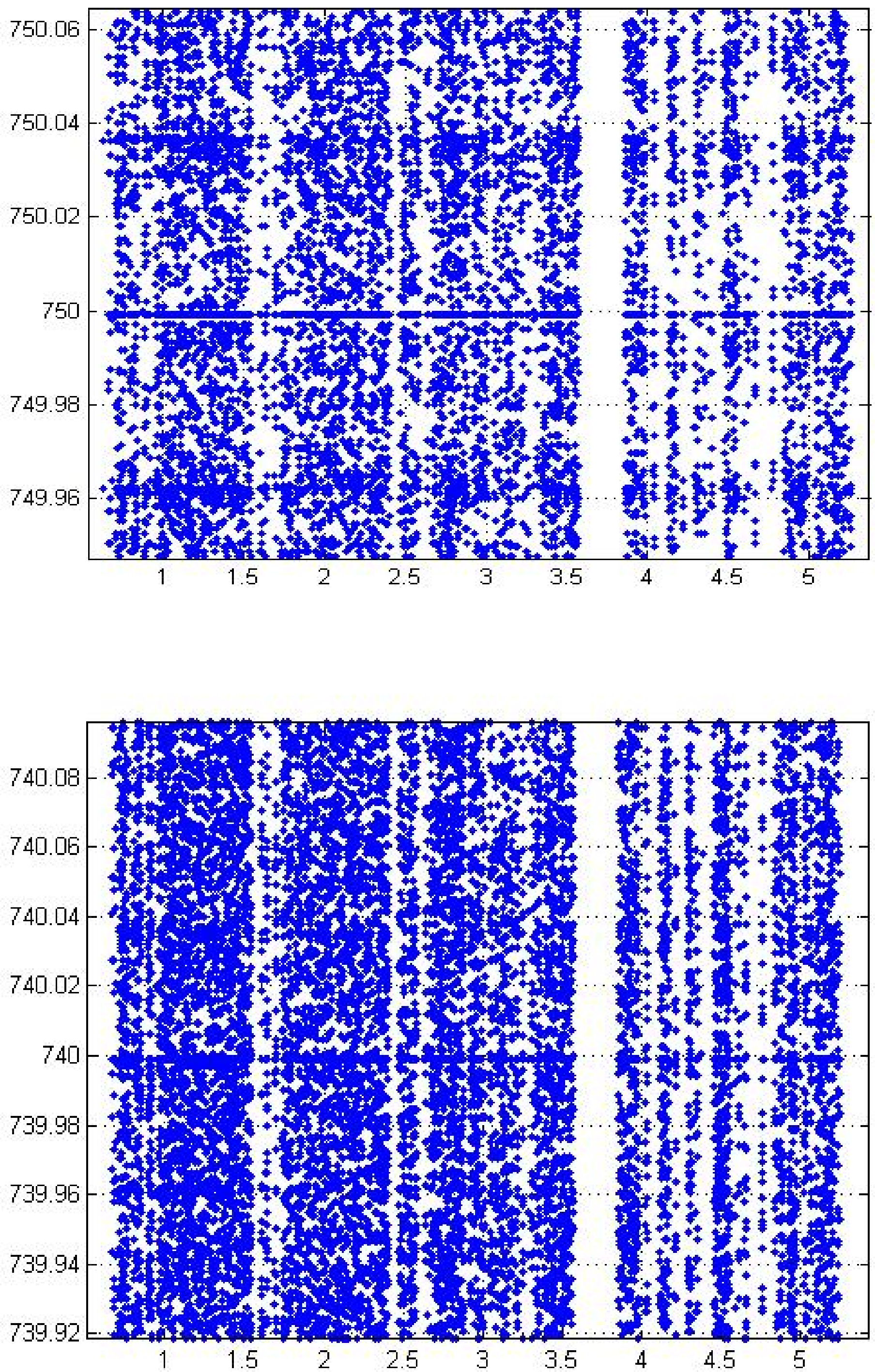
We can see that some lines have side bands (i.e., they are slightly modulated in amplitude in time, with periods of tens of seconds).



Here the side bands are two, meaning two periodicities in modulation.

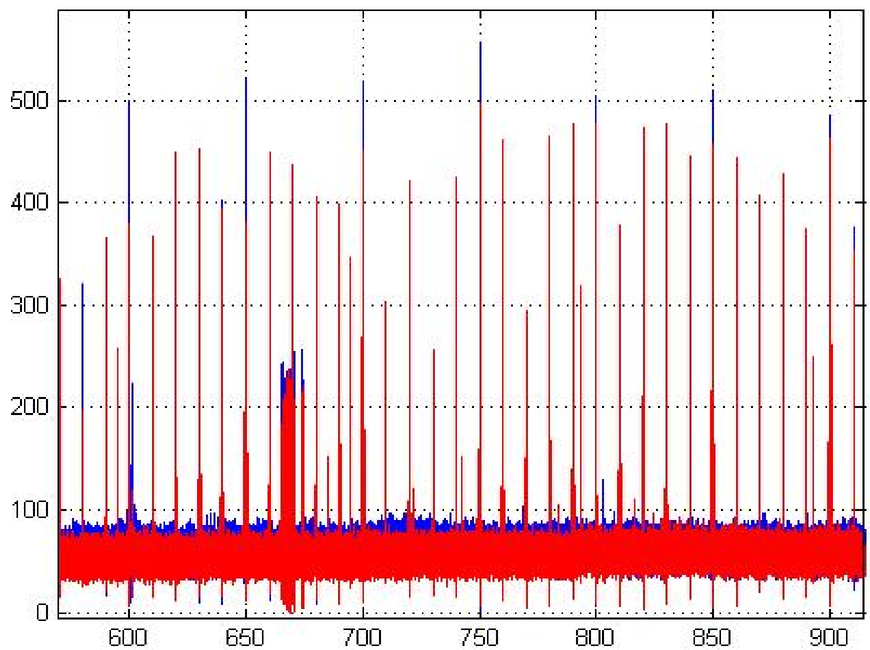


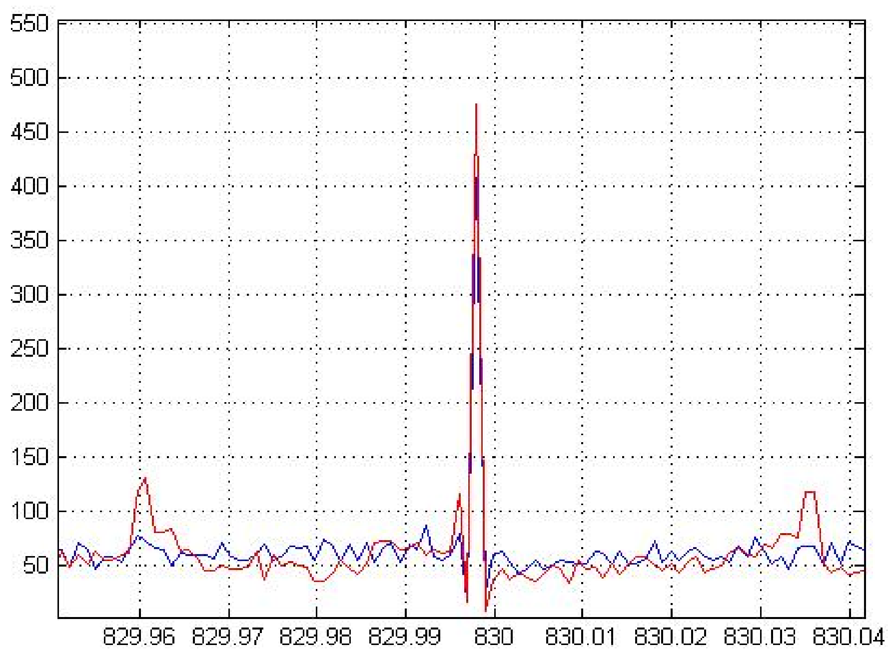
time-frequency



C6-C7

In this plot C6 is plotted in blue, C7 in red.





Sampled data spectrum

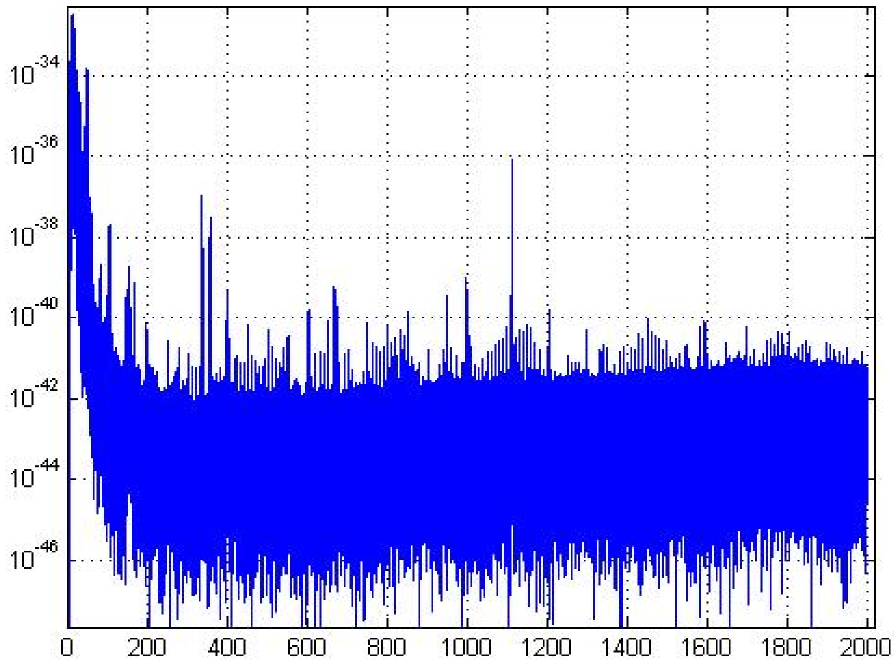
Now let us take the h-reconstructed data (on the base of which the peak maps were built) and let us see as the 10 Hz effect appears.

We get some sampled data from C7 run with

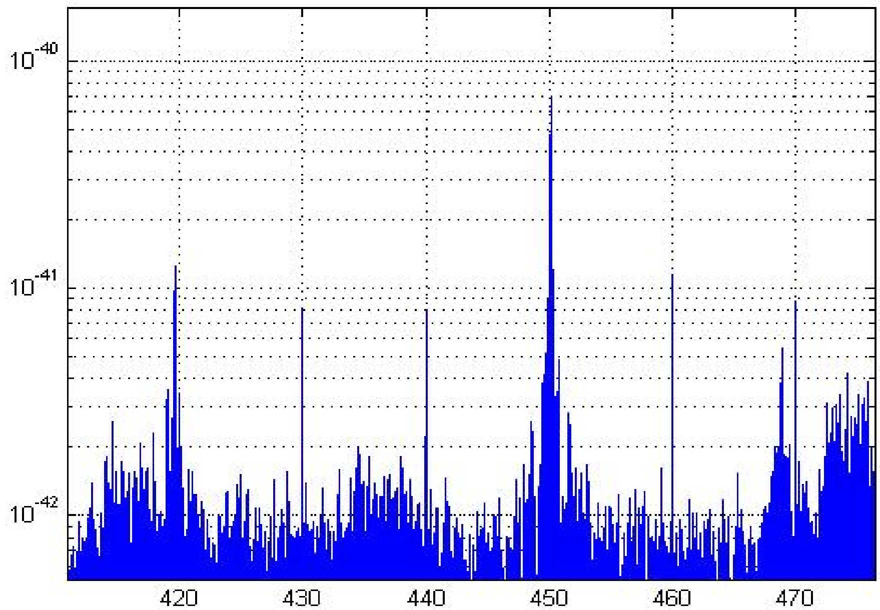
```
g1=sds2gd_selind('VIR_hrec50Hz_20050915_043340_.sds',1,0*4194304+1,1*4194304)
```

The choice of the data was done in order to peek more clear results.

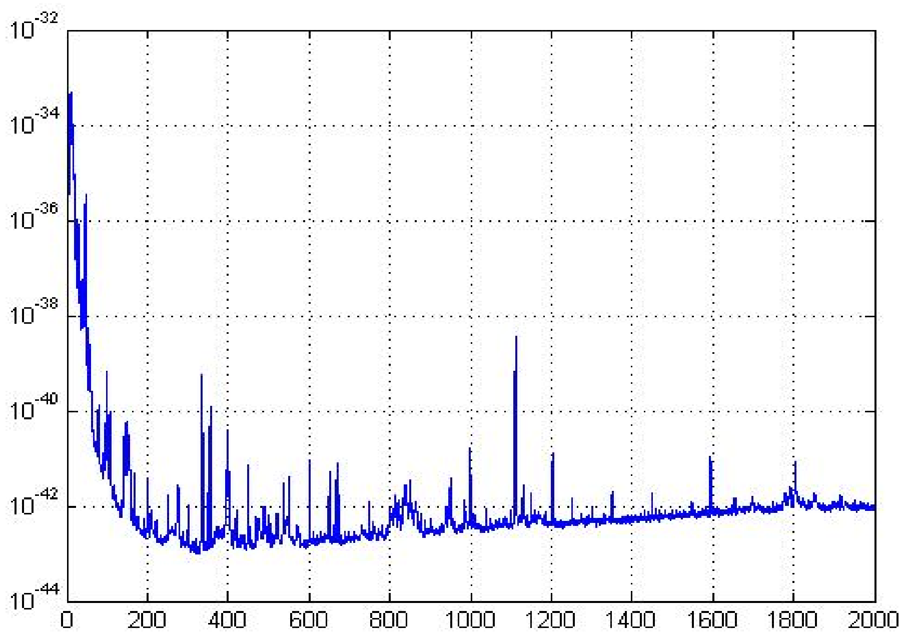
Here is the spectrum:



and here is a zoomed band



with smoothed value (averaging 256 pieces)



At this scale, the effect disappear.

The pulses – model and reality

The periodic delta model

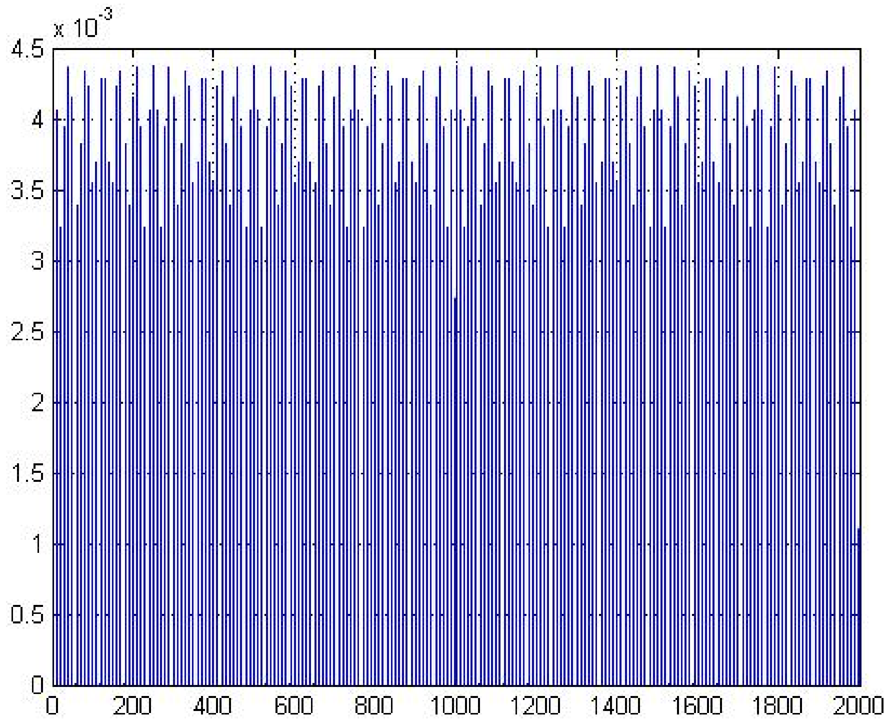
The possible cause of this effect is the presence of a sequence of narrow pulses, with the frequency of 10 Hz.

Let us create a sequence of pulses with

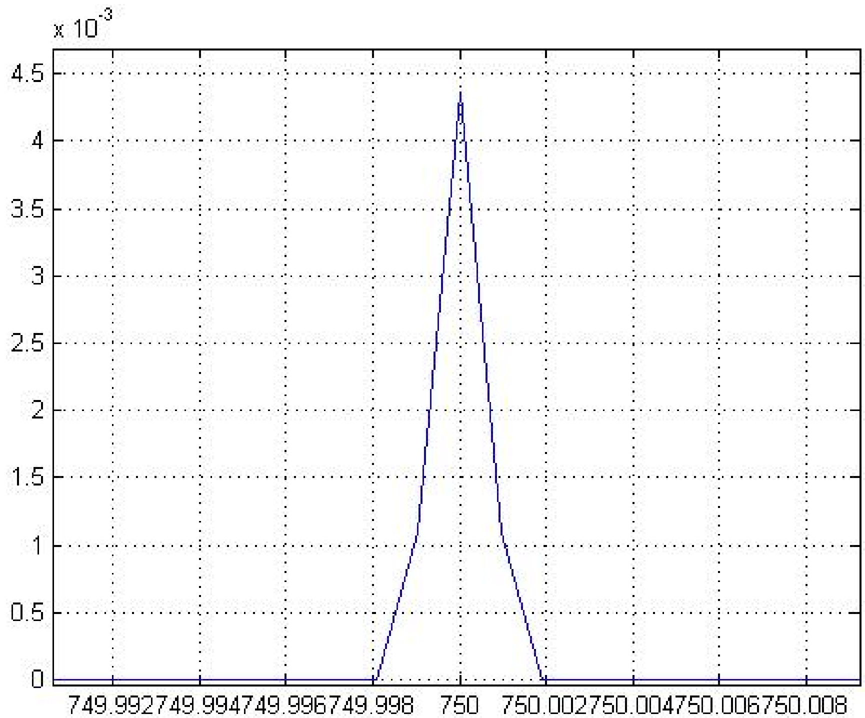
```
>> m3=zeros(2^22,1);
>> ii=round(1:400:2^22);
>> m3(ii)=1;
>> m3=gd(m3)
>> m3=edit_gd(m3,'dx',0.00025)
```

In such a way 10486 events are created, with frequency of 9.9999750 Hz and period 0.100000250 s.

The power spectrum of this signal is



and the zoom around one peak is



Let us estimate the amplitude of the “real data” deltas.
The procedure is the following: from the model we find that from the ratio between the delta amplitude and the square root of the spectral peak amplitude is about 20, so, estimating the amplitude of the spectral peaks we can find the delta amplitude.

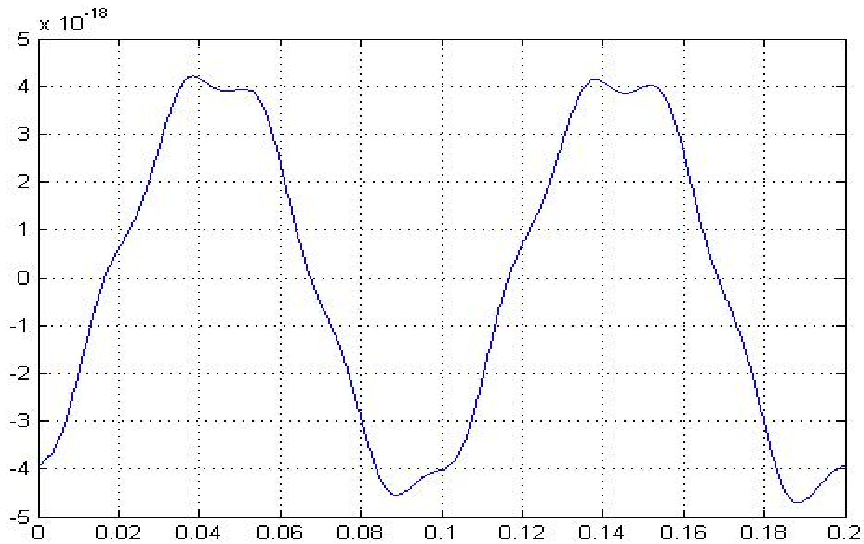
Roughly it is of the order of 10^{-20} .

Can we see these pulses ?

Searching for real pulses - the comb-filter + epoch-folding procedure

Let us start from data sampled data used for the spectrum of the preceding section. They have a standard deviation of about 6.5e-017, so we have no hope.

Let us use the epoch-folding method for searching for periodicities. We find

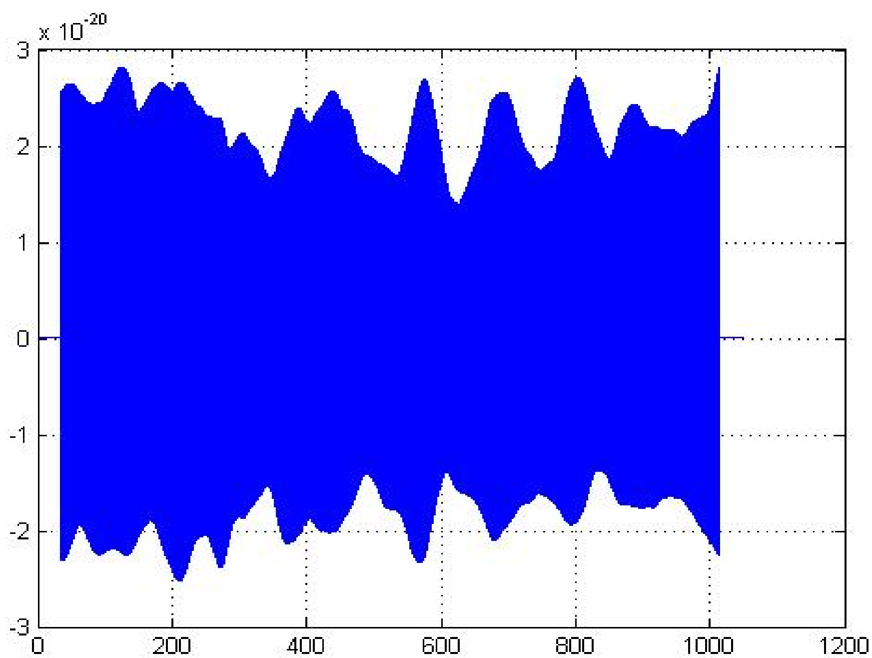


given the amplitude, also in this case no hope.

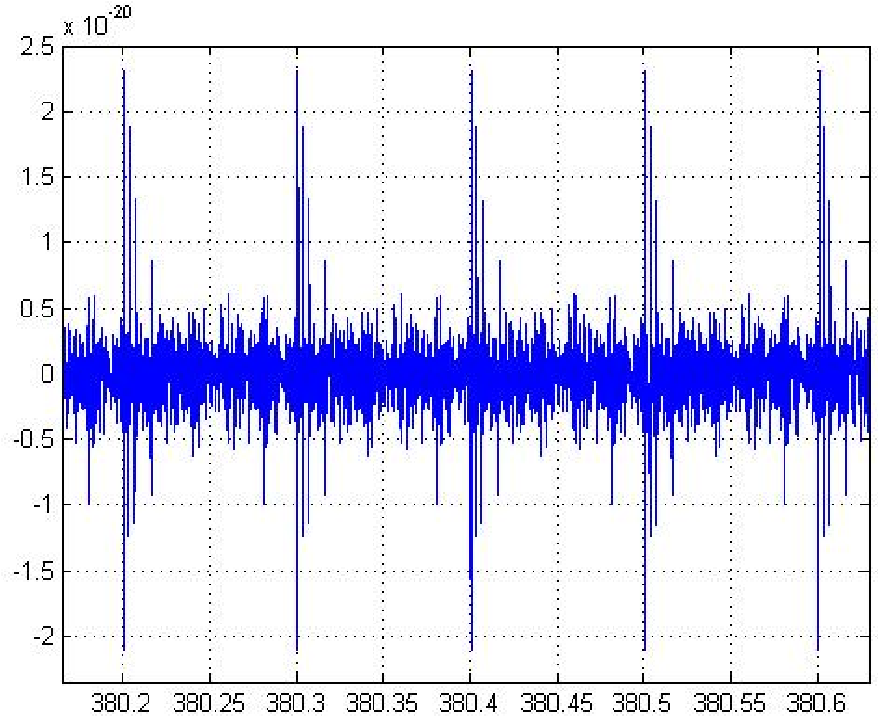
Then we constructed a comb filter with high pass at 200 Hz and holes at multiples of 50 Hz and then, on the output, we apply the epoch-folding on the basis of two periods (0.2 s). This is the procedure

```
>> g1=sds2gd_selind('VIR_hrec50Hz_20050915_043340_.sds',1,0*4194304+1,1*4194304)
>> yi=comb_10hz(g1);
>> gout=gd_epochfold(yi,0.2)
```

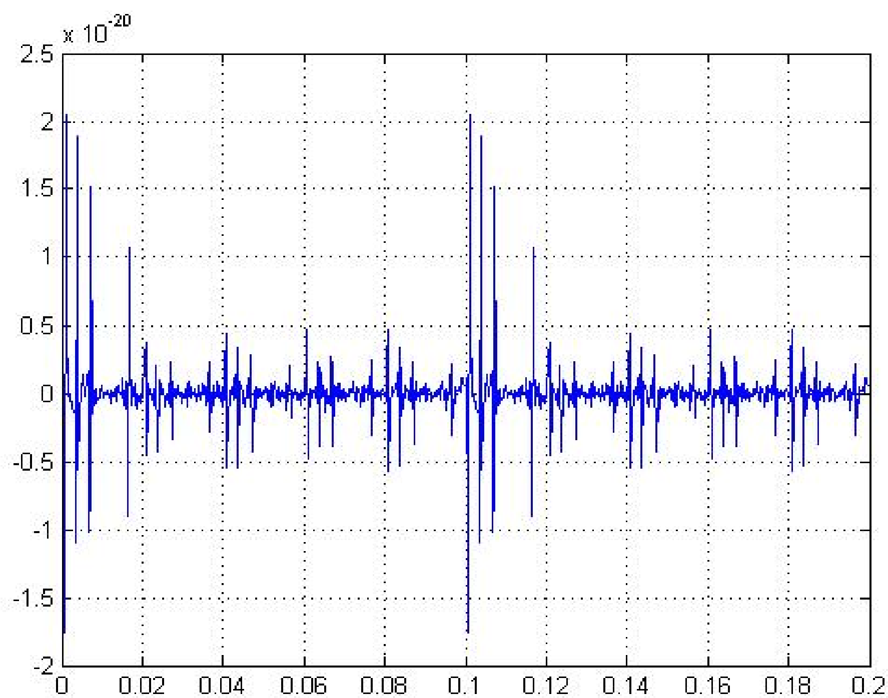
After the comb filter (and before the epoch folding), we have



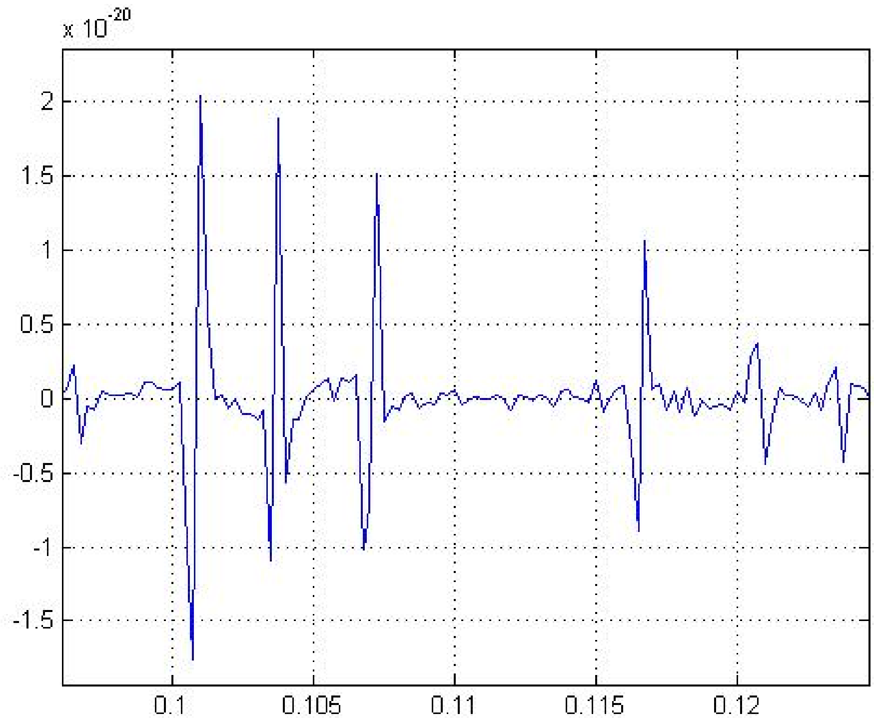
and zooming we have



After the epoch folding (over two periods, i.e. 0.2 s), we have :

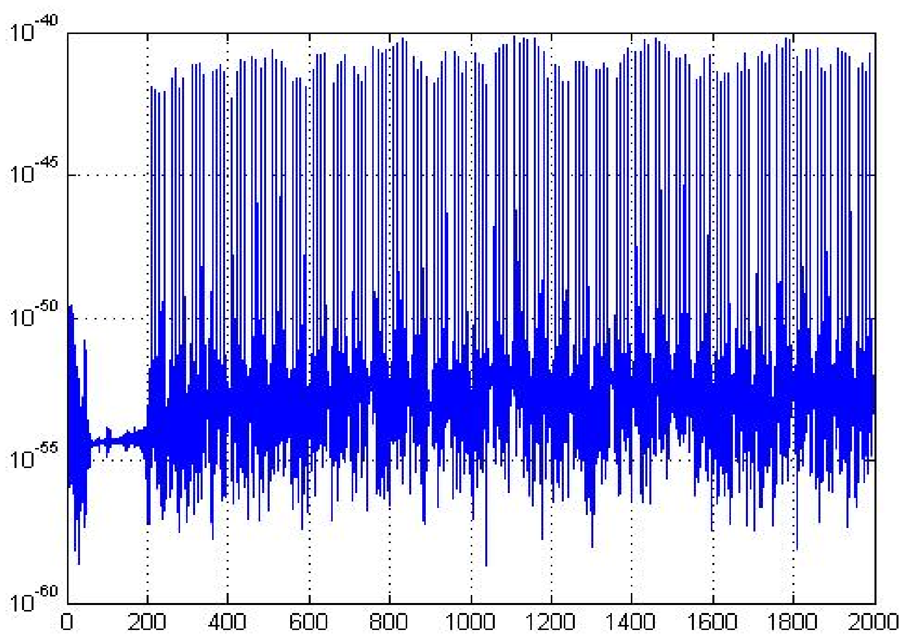


and zooming the starting part

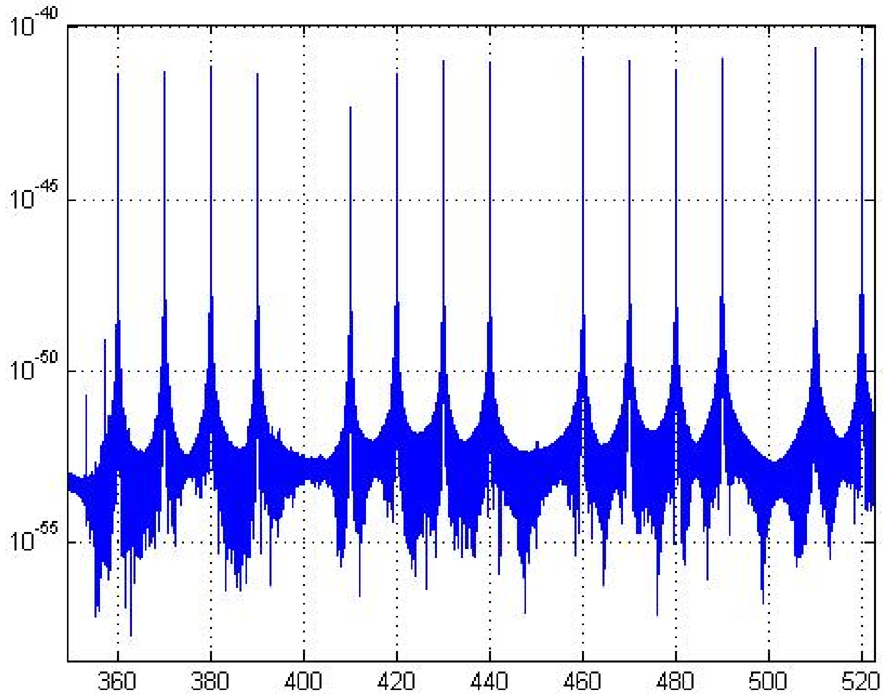


Note that this is not the true pulse shape, but the pulses as seen in the observed band.
Note the synchronization with the true tenth of second.

Here is the spectrum of the signal after the comb filter:



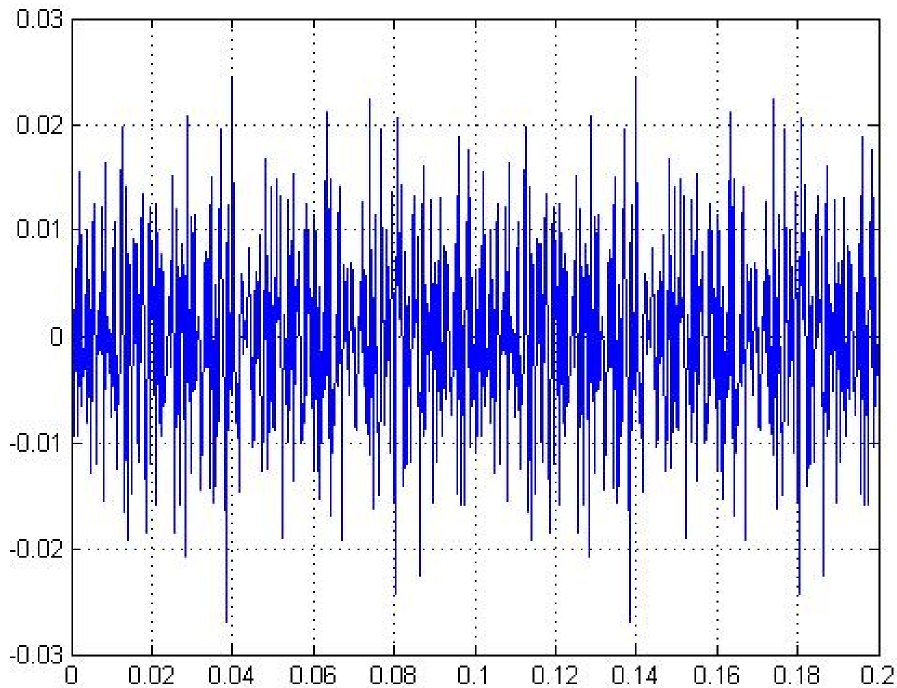
and the zoom:



Note the cut at low frequencies and at the multiples of 50 Hz.

Our procedure applied to white noise

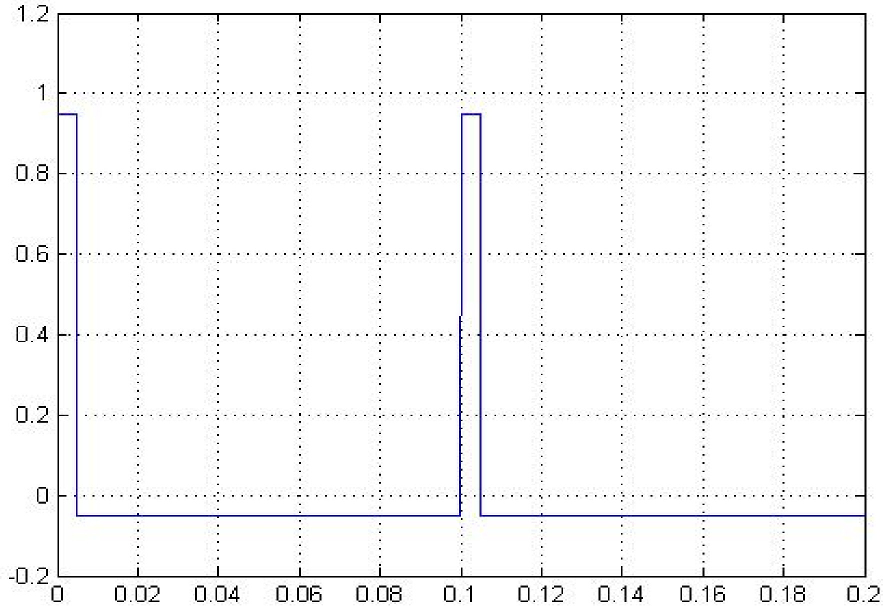
To understand better the procedure comb filter + epoch folding, let us apply it to white gaussian noise with unitary standard deviation. We have



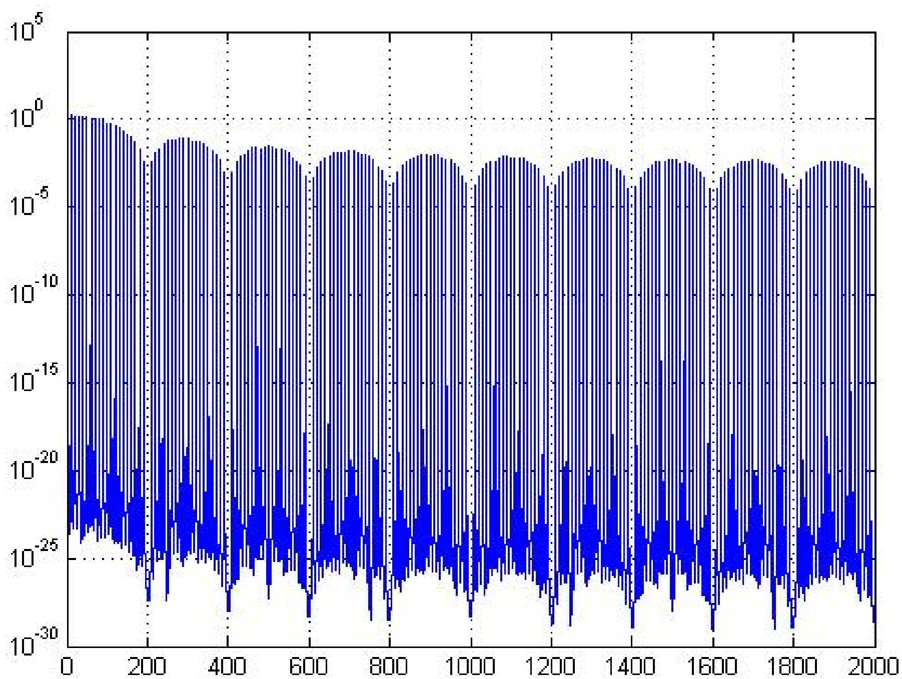
i.e., we have a two-periods periodic white noise, with standard deviation 0.0085.

Our procedure applied to rectangular pulses

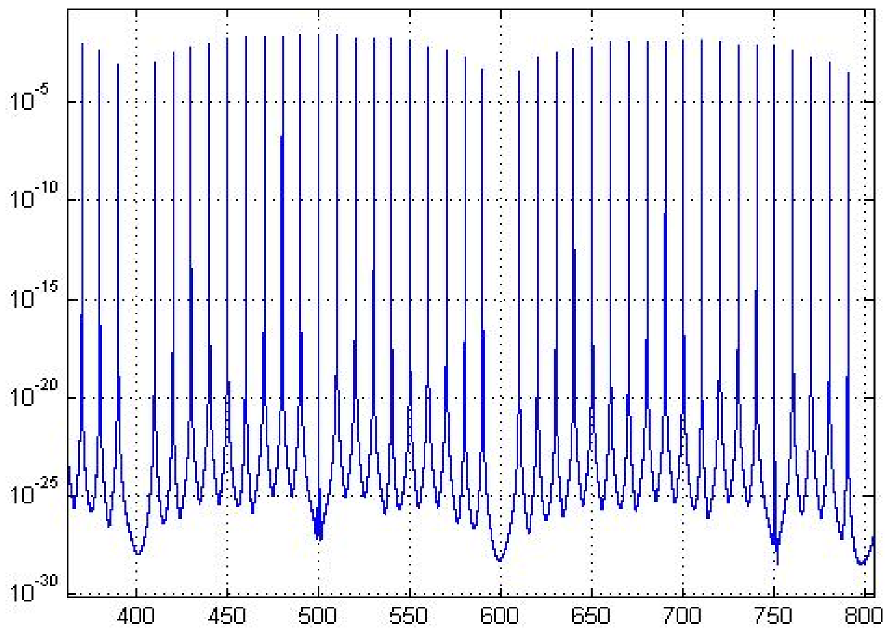
If we apply the same procedure to a train of pulses of shape



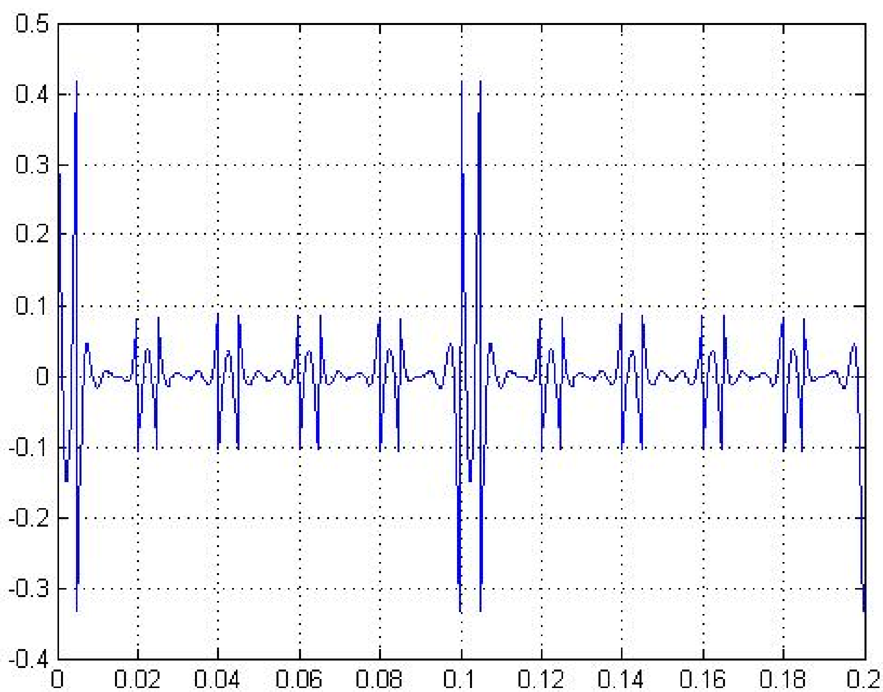
They have the spectrum



and zoomed

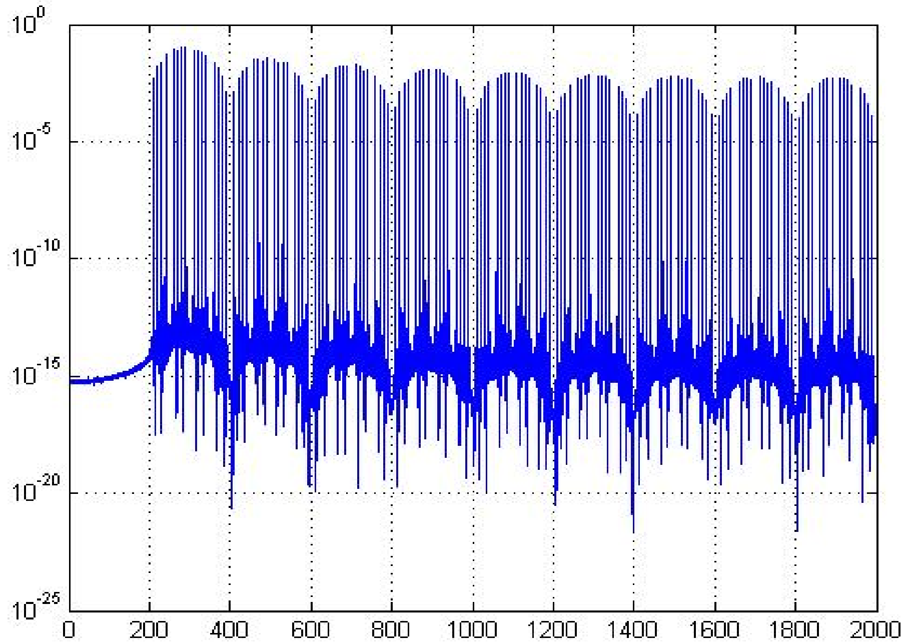


After the comb filter the pulse becomes

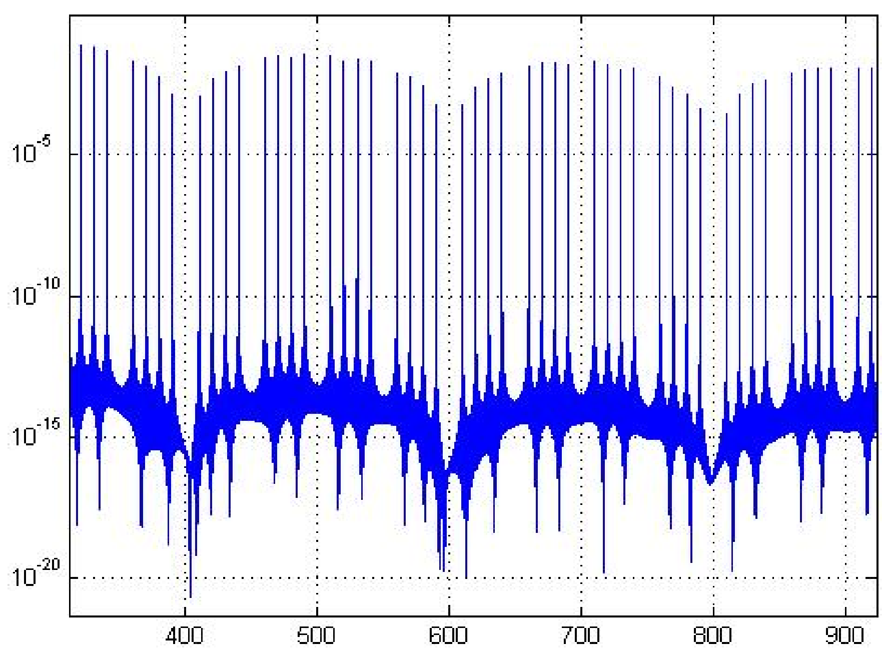


Note that the amplitude is about one half of the original pulses. This gives us what is the difference between the real data and the observed data after our procedure.

The spectrum after the comb filter is



and zoomed



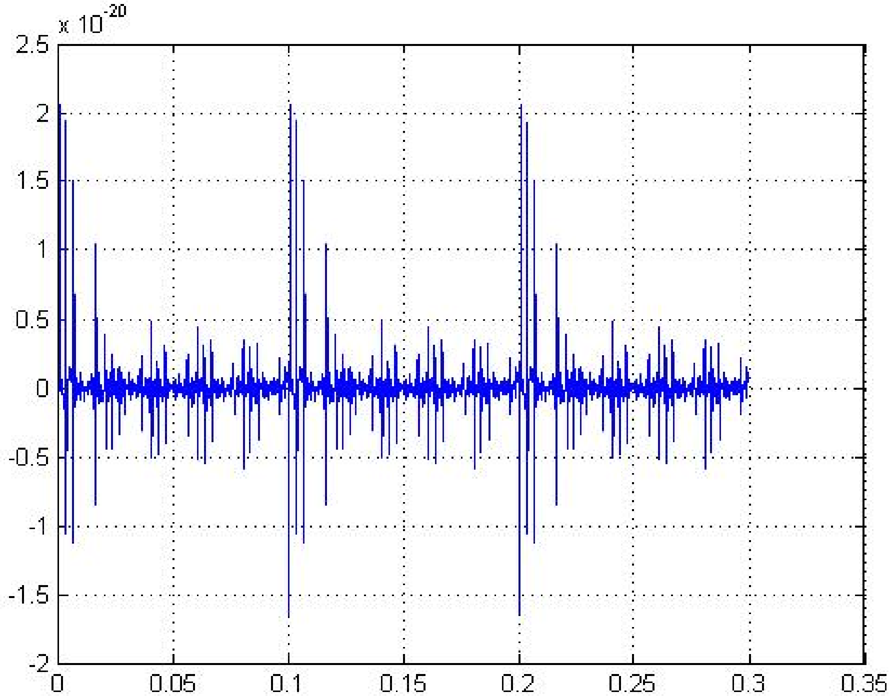
Verification

Now we apply the same procedure to other data:

Same file, other data. With

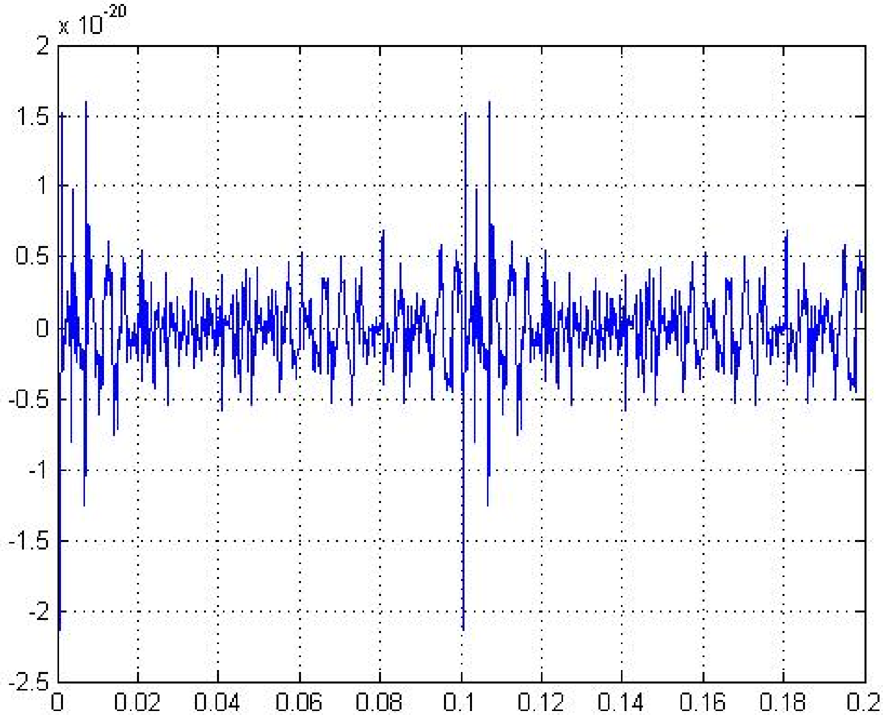
```
>> g1=sds2gd_selind('VIR_hrec50Hz_20050915_043340_.sds',1,8000001,12194304)
>> yi=comb_10hz(g1);
>> gout=gd_epochfold(yi,0.3)
```

we have

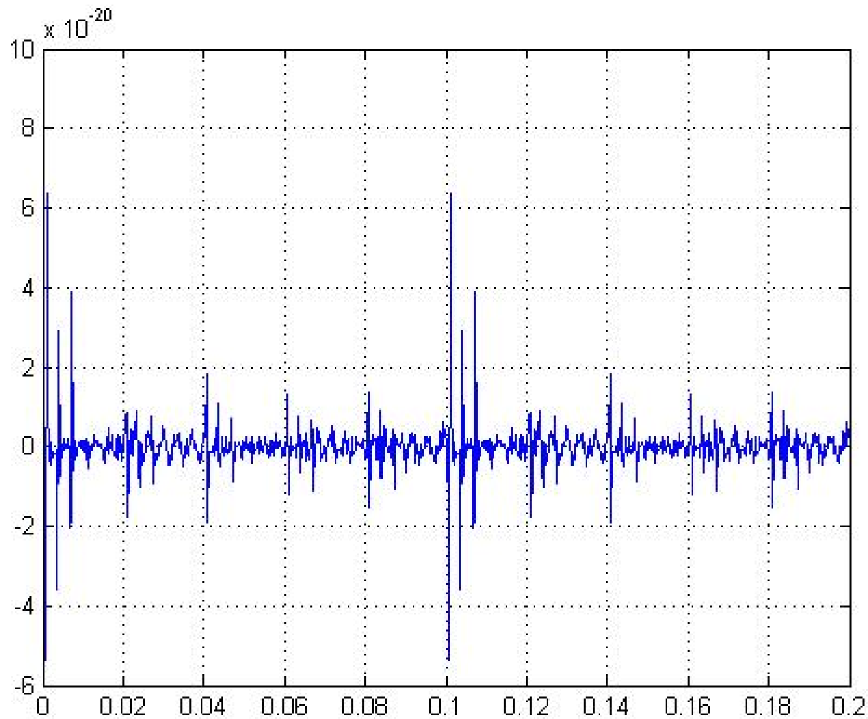


And now, let us go to other files (always showing two periods):

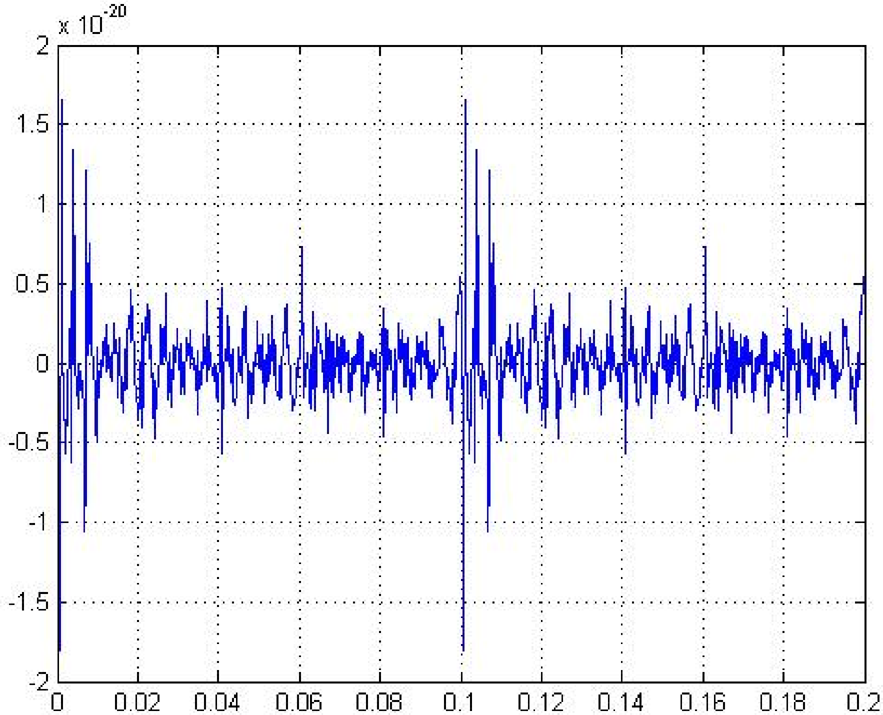
C6 - 'VIR_hrec_20050802_001627_.sds' (samples 8000001 - 12194304)



C6 - ' VIR_hrec_20050804_105307_.sds'



C6 - ' VIR_hrec_20050809_131627_.sds'



No clear evidence of this effect has been found in C4 and C5 data.

Conclusions

- There are periodic pulses in the data of C6 and C7, with period 10 Hz.

- These pulses, as seen in the permitted frequency window, have a complex shape, slightly varying in different periods. The most important feature is that they have a very narrow peak (normally the highest) at the exact deci-second, followed by other two within 0.007 s.

- The effect is relatively larger in the C7 data, also if its amplitude in h is lower. Here is a rough table of the amplitudes and the after detection SNR:

run	amplitude	after detection SNR
C4	-	-
C5	-	-
C6	$1 \sim 6 \cdot 10^{-20}$	8
C7	$2 \cdot 10^{-20}$	12

- This effect must be taken in account in the periodic source search. This can be done by cancelling the peaks at that frequencies. This reduces a little the sensitivity for a small fraction of the antenna band.

- This effect can be more dramatic for pulse searcher. But can be used positively for check purposes.

- To understand better the problem for the noise team: in the C7 there are 864000*3 spurious pulse per day, with an amplitudes of some units of 10^{-20}.