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ANALYSIS AND MONITORING PROGRAMS

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Abstract: The paper presents a program for monitoring and control method for any gearbox and equipments. These sources are of a great interest for the gearing durability. The vibrations generated by these sources and together with them the dynamic forces and the noise become very strong high, especially when the frequency of the perturbation sources which is always in a relation determined by the gearing revolutions superposes on a frequency of it's own – the resonance phenomenon appears.

The method of analysis used is dual channel and has editing features that make it the best for identification and separation of harmonics families using cepstrum analysis.

The spectrum of a gearbox signal will usually consist of a number of harmonic families. These harmonic families originate from the different shafts and ball-bearings in the gearbox, and from the tooth meshing frequencies of the gears. The gears usually have numbers of teeth equal to prime numbers. This is an advantage as it causes wear to be spread out more evenly on the teeth of the gears, but it is also an advantage from a measurement point of view, as it means that the different harmonic families will usually not overlap.

On the other hand, there can often be several harmonic families, and it can be difficult to separate them in the spectrum. Cepstrum is a practical tool that makes it easy to find these different harmonic families, and the individual families can be monitored for changes that might indicate that something is wrong.

In figure 1. is presented the block scheme of the program.

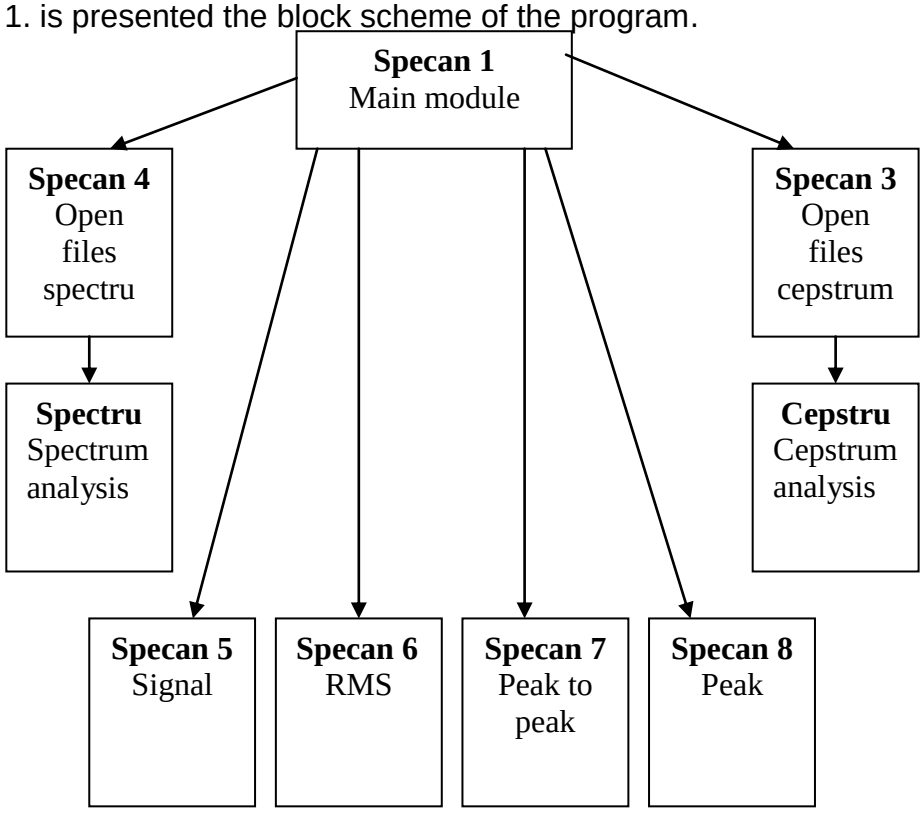

Figure 1. Block diagram for analysis of results

- 1. PROGRAMUL PRINCIPAL *SPECAN 1*-

This program defines the graphical user interface, creating a menu from where subprograms can be selected: *specan 3, specan 4, specan 5, specan 6, specan 7* şi *specan 8.*

```
% Initializare variabile
% Definire interfaţa grafica utilizator : "specan1"
global contor x1 calibrare;
fre_esant = 20000;
nr_esant = 16384;
contor = 1;
% Calibrare semnal
%Transformare in volti
calib1 = (10/4096);
% Constanta traductorului KD42
kd42 = 0.0415;
        kd35 = 0.0;
% Transformare in m/s^-2
% calibrare = calib1*9.81/kd42;
f40_1_1 = figure('Name','Analiza spectrala a semnalelor achizitionate',...
  'NumberTitle','off');
%'MenuBar','none',
% Butoane
f40_1_4_2  = uicontrol('Style', 'pushbutton', 'String', 'Semnal',...
  'Position', [5 5 70 20], 'Callback', 'specan5');
f40_1_4_3  = uicontrol('Style', 'pushbutton', 'String', 'Spectru',...
  'Position', [80 5 70 20], 'Callback', 'specan4');
f40_1_4_1  = uicontrol('Style', 'pushbutton', 'String', 'Cepstru',...
  'Position', [155 5 70 20], 'Callback', 'specan3');
f40_1_4_4  = uicontrol('Style', 'pushbutton', 'String', 'RMS',...
  'Position', [230 5 70 20], 'Callback', 'specan6');
f40_1_4_5  = uicontrol('Style', 'pushbutton', 'String', 'PEAK to PEAk',...
  'Position', [305 5 100 20], 'Callback', 'specan7');
f40_1_4_6  = uicontrol('Style', 'pushbutton', 'String', 'PEAK',...
  'Position', [410 5 70 20], 'Callback', 'specan8');
% Iesire
f40_1_6  = uicontrol('Style', 'pushbutton', 'String', 'Iesire',...
  'Position', [485 5 70 20], 'Callback', 'delete(f40_1_1)');
```

2. SUBPROGRAMUL *SPECAN 4*

This program takes as input the acquired data found in data files. After selecting the data files we use subprogram spectrum.

```
% Deschidere fisier si lansare spectru
global contor x1;
[filename,pathname] = uigetfile('*.*','Selectati fisierul de date',300,100);
if filename ~=0
        fid = fopen(strcat(pathname,filename),'r');
```

```
        [x1,count1] = fread(fid,inf,'int16');
        fclose('all');
        spectru;
elseif filename == 0
        disp('Nu s-a selectat nici un fisier');
end
```

3. SUBPROGRAMUL *SPECTRU*

Subprogram power spectrum spectrum analysis performed using Fourier transform. After defining the constants and their constant depending on transducer type, signal filtering is done by calling function Hanning (Hann). Applying the Fourier transform (FFT) result is obtained in frequency domain [dB].

```
% Calcul si afisare Spectru
% Constante program
global x1;
fre_esant = 20000;
nr_esant = 2^16; % trebuie sa fie o putere a lui 2
pct_med = 128; % trebuie sa fie o putere a lui 2
domeniu_plot_frecv = 3200;
% Calibrare semnal
% Transformare in volti
x1 = x1.*(10/4096);
% Se scade valoarea offset
x1 = x1 - mean(x1);
% Constanta traductorului KD42
kd42 = 0.0415;
kd35 = 0.0439;
% Calibrare
x1 = x1./kd35;
% Transformare in m/s^2
x1 = x1*9.81;
% Generare filtru
H = hann(pct_med)/pct_med;
% Spectru
amp = 20*log10(real(fft(x1,nr_esant)).^2/(10^(-5)));
amp = amp(1:nr_esant/2);
amp = abs(amp);
% Medie
amp = conv(H,amp);
% Grafic spectru
amp = abs(amp(pct_med/2:length(amp)-(pct_med/2)));
frecv = (0:length(amp)-1)*fre_esant/nr_esant;
frecv = frecv(:);
dom_spec = floor(domeniu_plot_frecv*nr_esant/fre_esant);
figure;plot(frecv(10:dom_spec),amp(10:dom_spec),'k');
title(strcat('Spectru semnal'));
xlabel('Frecventa [Hz]');
ylabel('dB (m/s^2)');
```

4. SUBPROGRAMUL *SPECAN 3*

This program receives input data that are acquired in data files. After selecting the data files we use subprogram Cepstru*.*

```
% Deschidere fisier si lansare Cepstru
global contor x1;
[filename,pathname] = uigetfile('*.*','Selectati fisierul de date',300,100);
if filename ~=0
        fid = fopen(strcat(pathname,filename),'r');
        [x1,count1] = fread(fid,inf,'int16');
        fclose('all');
        cepstru;
elseif filename == 0
        disp('Nu s-a selectat nici un fisier');
end
```

5. SUBPROGRAMUL *CEPSTRU*

Cepstru subprogram performs the analysis of the signal cepstrum purchased. After defining the constants associated with each type of sensor is its own steady. Analyzed signal is filtered through filter Hanning (Hann function - which carry signal mediation) after running and displays the cepstrum analysis result.

```
% Calcul si afisare Cepstru
% Constante program
        global x1
        fre_esant = 20000;
        nr_esant = 2^16; % trebuie sa fie o putere a lui 2
        durata = 5;
        pct_med = 64; % trebuie sa fie o putere a lui 2
        domeniu_plot_frecv = 3200;
        domeniu_plot_timp = 0.128;
%Transformare in volti
 x1 = x1.*(10/4096);
% Se scade valoarea offset
 x1 = x1 - mean(x1);
% Constanta traductorului KD42
kd42 = 0.0415;
kd35 = 0.0439;
% Calibrare
x1 = x1./kd35;
%Transformare in m/s^2
x1 = x1*9.81;
% Generare filtru
H = hann(pct_med)/pct_med;
% Spectru
amp = real(fft(x1,nr_esant)).^2;
amp = amp(1:nr_esant/2);
```

```
amp = abs(amp);
% Filtrare (mediere cu filtru Hanning)
amp = conv(H,amp);
amp = abs(amp(pct_med/2:length(amp)-(pct_med/2)));
frecv = (0:length(amp)-1)*fre_esant/nr_esant;
frecv = frecv(:);
dom_spec = floor(domeniu_plot_frecv*nr_esant/fre_esant);
% Logaritm
amp = 20*log10(amp/(10^(-5)));
% Ifft
amp_ceps = abs(real(ifft(amp)));
% Grafic cepstru
timp_ceps = (0:length(amp_ceps)-1)/fre_esant;
dom_ceps = floor(domeniu_plot_timp*fre_esant);
figure;plot(timp_ceps(10:dom_ceps),amp_ceps(10:dom_ceps),'k');
title(strcat('Cepsrum'));
xlabel('Timp [s]');
ylabel('dB (m/s^2)');
```

6. SUBPROGRAMUL *SPECAN 5*

This program takes the piezoelectric transducer signal acquired from the data file and displays it.

```
% Deschidere fisier si afisare semnal
global contor x1;
[filename,pathname] = uigetfile('*.*','Selectati fisierul de date',300,100);
if filename ~=0
        fid = fopen(strcat(pathname,filename),'r');
        [x1,count1] = fread(fid,inf,'int16');
        fclose('all');
        count1 = 100000;
        x1 = x1(1:count1);
        timp  = [1:count1]/20000;
        % Calibrare semnal
        %Transformare in volti
        x1 = x1.*(10/4096);
        % Se scade valoarea offset
        x1 = x1 - mean(x1);
        % Constanta traductorului KD42
        kd42 = 0.0415;
        kd35 = 0.0439;
        % Calibrare
        x1 = x1./kd35;
        %Transformare in m/s^2
         x1 = x1*9.81;
        %Afisare
        f_1 = figure('Name','Semnal',...
        'NumberTitle','off');
        plot(timp,x1,'k');
```

```
        title(strcat('Semnal traductor piezoelectric'));
        xlabel('Timp [s]');
        ylabel('Acceleratie [g]');
elseif filename == 0
        disp('Nu s-a selectat nici un fisier');
end
```

7. SUBPROGRAMUL *SPECAN 6*

To determine the statistical feature $RMS = \sqrt{\frac{\sum_{i-1}^{n}(x_i)^2}{n}}$ subprogram ***specan 6*** calculates and displays the value for each signal acquired.

```
% Calcul si afisare RMS
global contor x1;
[filename,pathname] = uigetfile('*.*','Selectati fisierul de date',300,100);
if filename ~=0
        fid = fopen(strcat(pathname,filename),'r');
        [x1,count1] = fread(fid,inf,'int16');
        fclose('all');
        % Calibrare semnal
        %Transformare in volti
        x1 = x1.*(10/4096);
        % Se scade valoarea offset
        x1 = x1 - mean(x1);
        % Constanta traductorului KD42
        kd42 = 0.0415;
        kd35 = 0.0439;
        % Calibrare
        x1 = x1./kd35;
        %Transformare in m/s^2
        x1 = x1*9.81;
        % Calcul RMS
         x1_rms = (sqrt(sum(x1.^2)/size(x1,1)));
         x1_rms_str = num2str(x1_rms);
        % Afisare
        f46_1_4_1  = uicontrol('Style', 'Text', 'String', x1_rms_str,...
          'Position', [20 305 70 20]);
        f46_1_4_2  = uicontrol('Style', 'Text', 'String', 'RMS',...
          'Position', [20 330 70 20]);
elseif filename == 0
        disp('Nu s-a selectat nici un fisier');
end
```

8. SUBPROGRAMUL *SPECAN 7*

This program calculates and displays the value of statistical characteristic time between the maximum and minimum values of signal.

```
 %Calcul si afisare Peak to Peak
global contor x1;
[filename,pathname] = uigetfile('*.*','Selectati fisierul de date',300,100);
if filename ~=0
        fid = fopen(strcat(pathname,filename),'r');
        [x1,count1] = fread(fid,inf,'int16');
        fclose('all');
        % Calibrare semnal
        %Transformare in volti
        x1 = x1.*(10/4096);
        % Se scade valoarea offset
        x1 = x1 - mean(x1);
        % Constanta traductorului KD42
        kd42 = 0.0415;
        kd35 = 0.0439;

        % Calibrare
         x1 = x1./kd35;
        %Transformare in m/s^2
        x1 = x1*9.81;
        %Calcul Peak to Peak
        x1_peak_to_peak = max(x1)-min(x1);
        x1_peak_to_peak_str = num2str(x1_peak_to_peak);
        %Afisare
        f46_1_4_1  = uicontrol('Style', 'Text', 'String', x1_peak_to_peak_str,...
          'Position', [95 305 70 20]);
        f46_1_4_2  = uicontrol('Style', 'Text', 'String', 'PEAK to PEAK',...
          'Position', [95 330 100 20]);
elseif filename == 0
        disp('Nu s-a selectat nici un fisier');
end
```

9. SUBPROGRAMUL *SPECAN 8*

This program calculates and displays the positive values of the maximum static characteristic signal.

```
% Calcul si afisare Peak
global contor x1;
[filename,pathname] = uigetfile('*.*','Selectati fisierul de date',300,100);
if filename ~=0
        fid = fopen(strcat(pathname,filename),'r');
        [x1,count1] = fread(fid,inf,'int16');
        fclose('all');
        % Calibrare semnal
        % Transformare in volti
        x1 = x1.*(10/4096);
        % Se scade valoarea offset
        x1 = x1 - mean(x1);
        % Constanta traductorului KD42
```

```
        kd42 = 0.0415;
        kd35 = 0.0439;
        % Calibrare
        x1 = x1./kd35;
        % Transformare in m/s^2
        x1 = x1*9.81;
        % Calcul Peak to Peak
        x1_peak = (max(x1)-min(x1))/2;
        x1_peak_str = num2str(x1_peak);
        % Afisare
        f46_1_4_1  = uicontrol('Style', 'Text', 'String', x1_peak_str,...
          'Position', [200 305 70 20]);
        f46_1_4_2  = uicontrol('Style', 'Text', 'String', 'PEAK',...
          'Position', [200 330 70 20]);
elseif filename == 0
        disp('Nu s-a selectat nici un fisier');
end
```

References

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