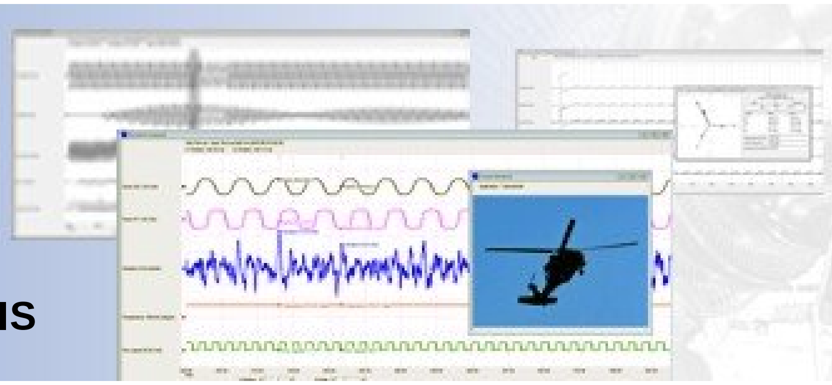
DAP102001

SPECTRUM ANALYSIS



Similar to other technical domains, numerical signal processing comprises two main operations: analysis and synthesis. Analysis is the process of decomposing a function (or other object) into components which are simple and easy to understand and interpret.

Sinus wave

In nature and in most industrial processes, we find conditions similar to the harmonic oscillator: a moving mass under the action of an elastic force.

According to Hooke's law, the elastic force is proportional to displacement and elasticity constant:

$$F_e = kx$$

Meanwhile, according to the reaction principle, the elastic force is equal in module and of contrary direction with the inertial force:

$$Fe = -Fi$$

The second Newton's law defines the inertial force as the product between mass and acceleration:

$$Fi = ma$$

Therefore, the displacement and acceleration of the oscillating movement have the same shape while they are proportional to each other:

$$kx = -ma$$

Knowing that speed is the simple integrate of acceleration and displacement is the double integrate of acceleration, we got the following differential movement equation:

$$m\frac{d^2x}{dt^2} = -kx$$

The solution of this equation looks like:

$x(t) = A\cos(\omega t - \varphi)$ where $\omega = \sqrt{\frac{k}{m}}$ is the resonance frequency

We find that the oscillating movement has a sinus shape, which is the only one that observes the initial condition $kx = -ma$.

One may notice that the resonance frequency does not depend on the movement amplitude, as it is a physical characteristic of the mass-material assembly. That allows using the resonance frequency as a main parameter in the identification of the operating status of the machines components.

In the electronic and power generation industries, the sinus waveform is used both as a useful signal and for the definition of the electric characteristics and operation regimes.

Thus, in the power generation industry, the sinus regime is the ideal operating regime, which is characterized by minimum loss and stress.

The following main parameters have been defined for that regime:

- RMS voltage: $V = \sqrt{\frac{1}{T}\int_0^T v^2(t)dt} = \frac{V_{peak}}{\sqrt{2}}$
- RMS current: $I = \sqrt{\frac{1}{T}\int_0^T i^2(t)dt} = \frac{I_{peak}}{\sqrt{2}}$
- Active power: $P = \frac{1}{T}\int_0^T p(t)dt = VI\cos\varphi$
- Reactive power: $Q = VI\sin\varphi$

Various operational conditions make the stationary regime be only a theoretical one, while we have a non-sinus regime in practice.

The calculation of the electrical parameters for the non-sinus regime is based on the decomposition of voltage and current into sinus (harmonic) components, and the further application of the definitions specific to the sinus regime:

- RMS voltage: $V = \sqrt{\frac{1}{T}\int_0^T v^2(t)dt} = \sqrt{V_0^2 + V_1^2 + ...V_n^2}$
- RMS current: $I = \sqrt{\frac{1}{T}\int_0^T i^2(t)dt} = \sqrt{I_0^2 + I_1^2 + ...I_n^2}$
- Active power: $P = \frac{1}{T}\int_0^T p(t)dt = V_0 I_0 + \sum_{n=1}^{\infty} V_n I_n \cos\varphi_n$
- Reactive power: $Q = \sum_{n=1}^{\infty} V_n I_n \sin\varphi_n$

The harmonics frequency is in direct relationship with the constructive components of the generator or load and represents the main parameter for the identification of the cause of the unwanted behavior.

FFT analysis

The Fourier analysis of signals is based on the processing called Fourier Transform (FT) for the analysis, and the Inverse Fourier Transform (IFT) for the synthesis.

FFT (Fast Fourier Transform) is a fast FT calculation algorithm which is used by most signal analyzers.

FT decomposes the analyzed signals into sinus functions, each one having its amplitude, frequency and phase. The contents in sinus components of the input signal is called frequency spectrum and is usually represented as an amplitude-frequency graph.

The results are being used for diagnosis or calculation in the frequency domain.

Spectrum analyzers

The current industry context, based on increased quality, competitiveness and efficiency for products and processes, the spectrum analyzers are supposed to play a more and more important role in the research, design, testing and diagnosis activity.

The main features of the spectrum analyzers are:
- Dynamic domain
- Sampling rate
- Frequency resolution
- Processing speed
- Analysis function accuracy
- Presentation, storage and transfer capabilities

The increase of the processing capacity, constructive and operating performance of the computing systems has resulted in their integration in the structure of the signal analyzers and therefore a new technical and business stage in this field.

DIGITLINE Automation

Email office@digitline.eu
Web www.digitline.eu