Biosignals from the point of view of biophysics/obcyclic signal courses

Common waveforms

We can visualize different waveforms using functions that show us the instantaneous size of the signal as a function of time. Some of such courses are characterized by **artificial signals**, which are often used to exchange information in technical devices and their properties, in biomedical devices they can be used for **testing** and **calibration** (see above), or they are often used for artificial excitation (i.e. **stimulation**) of biosignals for the purpose of diagnosis (**evoked potentials**), and last but not least, they are generated for **terapeutic purposes** (impulse therapy, diadynamic currents, etc.). Such courses are usually characterized by their precise geometric course, often also by periodic repetition.

On the other hand, e.g. biosignals associated with the heart or respiratory activity of the organism have **quasi-periodic** course, and we find a certain periodicity even in such at first glance chaotic records, for example EEG.

Signal periodicity

By a periodic signal we mean a signal that has an arbitrary course in the time interval $<0,T)$ and this course is identically repeated in each subsequent of length T. If we denote the size of the signal x(t) as

$x(t) = f(t)$ pro $0 <= t < T$(9)

then for any t we can define a periodic function x(t)

$x(t) = f(t – nT)$(10)

where is an integer chosen so that $0 <= t – nT < T$(11)

Then we call the time T [s] **the period time** and the quantity

f [Hz] = 1 / T [s](12)

we will call **the repetition frequency** of the given signal (abbreviated as **frequency** f).

Sine (harmonic) signal

From high school mathematics and physics, we recall the trigonometric functions sin(α)cos(α), which we know as periodic functions of the angle alpha with the period 2π [rad]. We portray them as certain ratios between the sides of right-angled triangle or as Cartesian coordinates of a vector circling the unit circle with a frequency f [Hz], i.e. with an **angular frequency**

$\omega = 2 \pi f$(13)

or

$\omega = 2 \pi / T$(14)

(This **notion of angular frequency** can be **generalized** to any periodic signal.)

If we imagine that at v time $t_0 = 0$ [s] the starting angle $\alpha = \varphi$ [rad], then at v time t the angle of rotation α will have the size

$\alpha = \omega. t + \varphi$(15)

The angle alpha is therefore a linear function of a time with a proportionality constant ω and an additive constant φ. Function

$x(t) = \sin(\alpha) = \sin(\omega. t + \varphi)$(16)

then it will be periodic with a period

$T = 2 \pi / \omega$(17)

as follows from relation (14).

A sinusoidal signal will then be a signal which waveform will be expressed as

$x(t) = a. \sin(\alpha) = a. \sin(\omega. t + \varphi)$(18)

where*a* represents **the amplitude** of the signal, given in v **the appropriate physical units** according to the physical nature of the signal (voltage, current, pressure, mechanical deflection, etc.), ω is **the angular frequency** [rad/s], t is the time [s] and φ [rad] represents **the phase** signal.

We can easily see that the thus shifted and enlarged signal is also periodic with the period T, given by (17). Hence, also the signal, expresses as

$x(t) = a.\ \cos(\alpha) = a.\ \cos(\omega.\ t)$(19)

will have the same period, since this is (18) for the case $\varphi = \pi/2$.

Signals with such a sine or cosine waveform are also called harmonic signals (i.e. signals with a harmonic waveform).

Links

Resources

- HEŘMAN, Petr. *Biosignály z pohledu biofyziky.* 1. edition. Praha : Petr Heřman – DÚLOS, 2006. 64 pp.

Recommended literature

- AMLER, Evžen, et al. *Praktické úlohy z biofyziky I.* 1. edition. Praha : Praha: Ústav biofyziky 2. lékařské fakulty UK, 2006.
- HRAZDIRA, Ivo. *Biofyzika : učebnice pro lékařské fakulty.* 2. edition. Praha : Avicenum, 1990. ISBN 80-201-0046-6.
- KHAN, M. I. Gabriel. *EKG a jeho hodnocení.* 1. edition. Praha : Grada, 2005. ISBN 80-247-0910-4.
- KOMÁREK, Vladimír, et al. *Dětská neurologie.* 1. edition. Praha : Galén, 2008. ISBN 80-7262-492-8.
- ROSINA, Jozef, et al. *Lékařská biofyzika.* 1. edition. Praha : Manus, 2000. 0 pp. ISBN 80-902318-5-3.
- NAVRÁTIL, Leoš – ROSINA, Jozef. *Biofyzika v medicíně.* 1. edition. Praha : Manus, 2003. 398 pp. ISBN 8086571033.
- NAVRÁTIL, Leoš – ROSINA, Jozef, et al. *Medicínská biofyzika.* 1. edition. Praha : Grada, 2005. ISBN 80-247-1152-2.