**SiSy Test:**

**Introduction + Fourier Series**

# Exercise-1 Fourier Series 3D-Plot

1. Run and study the code of the Matlab demo files implementing the Fourier synthesis of different periodic functions:

*Fourier\_series\_3D\_graph\_step\_1.m*

*Fourier\_series\_3D\_graph\_step\_2.m*

What are the difference between these two scripts? Which effect does this difference have?

On Lab2a, you find an extract of a Fourier series table from:

**R. Kories, H. Schmidt-Walter, „*Taschenbuch der Elektrotechnik*“,**

Tabelle: Fourier-Reihen aus Kapitel 7.2.6 aus

9., korrigierte Auflage, Verlag Harri Deutsch, 2010.

1. Compare the f(t) equations from the Fourier series table to the expression of a Fourier series with real coefficients ak and bk. Determine the coefficients ak and bk for at least 4 functions, and verify your ak and bk expressions by modifying the corresponding lines in the Fourier synthesis Matlab script. As result show the changed code lines and corresponding plots.
2. Now study the following Matlab script: *Fourier\_series\_3D\_graph\_step\_3.m*

Here the single harmonics are stored in separated lines of a matrix. These harmonics are then plotted in a 3D plot in script: *Fourier\_series\_3D\_graph\_step\_4.m*

1. Modify the step\_4 script to implement one of the functions you tried out in item (b). As result show the changed code lines and corresponding plots.
2. Expand the script step\_4 to calculate the following coefficients:

* Ak and phik : Fourier series Real coefficients in polar notation
* ck : Fourier series complex coefficients

As result show the changed code lines. The resulting plots should be identical to item (d).

Tip: you can calculate Ak, phik, and ck using the relationships between Notation I, II and III of the Fourier series.

1. Then generate a plot of the single sided and double sided spectra.

Tip: Define an k vector which you can use for horizontal axis. For example for the single sided spectrum k = 0:1:M;

As result show the new code lines and corresponding plots.

# Exercise-2 Power in Time and Frequency Domain

1. Import the data file sisy\_test\_exer2.mat , and generate a plot of the two periodic signals s1(t) and s2(t). In the mat file you find the following variables: N (number of points), Fs (sampling frequency), s1\_t (1st periodic signal), s2\_t (2nd periodic signal).
2. Calculate P1\_t and P2\_t in Matlab corresponding to the total power of s1(t) and s2(t). Expecting a calculation with a numerical approximation of an integral in the time domain.   
   Express the power in (Vrms^2), that means relative to an impedance R=1 Ohm (normalised).
3. Calculate in Matlab the numerical approximation of the Fourier series of s1(t) and s2(t) using the fft function.
4. Calculate the power share of the harmonics according to the table below:

|  |  |  |
| --- | --- | --- |
| Signal | S1(t) | S2(t) |
| Total Power in Time Domain [Vrms ^2] |  |  |
| Power of 1st Harmonic  [Vrms ^2] |  |  |
| Power of 3rd Harmonic  [Vrms ^2] |  |  |
| Power of 1st & 3rd Harmonics  [Vrms ^2] |  |  |
| Power 1st & 3rd Harmonics  (as % of total power) |  |  |

# Exercise-3 Simple Pedometer (Step-Counter)

1. Use the IMU signal acquisition setup, which you prepared for laboratory 1-B, to log a sequence of 3D-accelerometer sensor data, while you walk for about 30 seconds.

*Hint:* you can start the acquisition, then place the smartphone in your pocket, and walk around for 30 seconds.

1. Import the sensor data in Matlab and process it to determine:

* Number of steps made during the whole acquisition period (step counter);
* Average frequency of the steps

Comment shortly your processing approaches.

Hints:

* Check the Matlab function findpeaks()
* Read the demo <https://ch.mathworks.com/help/matlabmobile_android/ug/counting-steps-by-capturing-acceleration-data.html> . But please notice, that on this demo the sensor data acquisition is made with another SW.

Background: a step counter is the 1st test of a [Gait Analysis](https://en.wikipedia.org/wiki/Gait_analysis) ([Ganganalyse](https://de.wikipedia.org/wiki/Ganganalyse)).