Application examples
EEG toolbox

Example: Determination of Event-Related Synchronization (ERD)

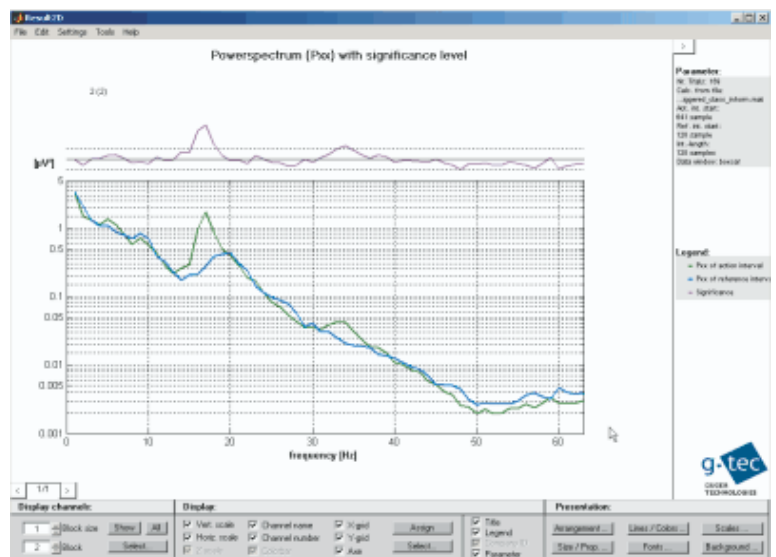### Power Spectral Density estimation (Fourier Transformation)

The **first step** in ERD quantification is to identify the subject's specific most reactive frequency bands. EEG during **right** hand and **foot** movement imagery was recorded over electrode positions C3 and Cz. The type of movement imagery was given via experimental instructions on the computer screen. A total of 160 imaginations of movements were performed (80 hand and 80 foot movements).

The analyze menu **Spectrum** allows you to compute the power spectral density (PSD) of your data. PSD is a measure of how power in a signal changes as a function of frequency. The spectral analysis detects periodic oscillations (amplitude and frequency) and has been employed in a great variety of signal processing applications.

g.BSanalyze allows you not only to compute the PSD for specific time segments, but also to **statistically compare** the PSD between data segments.

Hence differences in the PDS between **reference periods** versus **active periods** can be found easily.

The figure to the right displays the PSDs for an EEG signal in the reference period (color coded blue) and active period (color coded green). At a frequency of about 17 Hz, there is a significant amplitude difference between the 2 periods. The graph at the top (color coded violet) displays the amplitude difference. The dashed lines represent the 95% significance level. Values exceeding the dashed lines indicate significant differences.
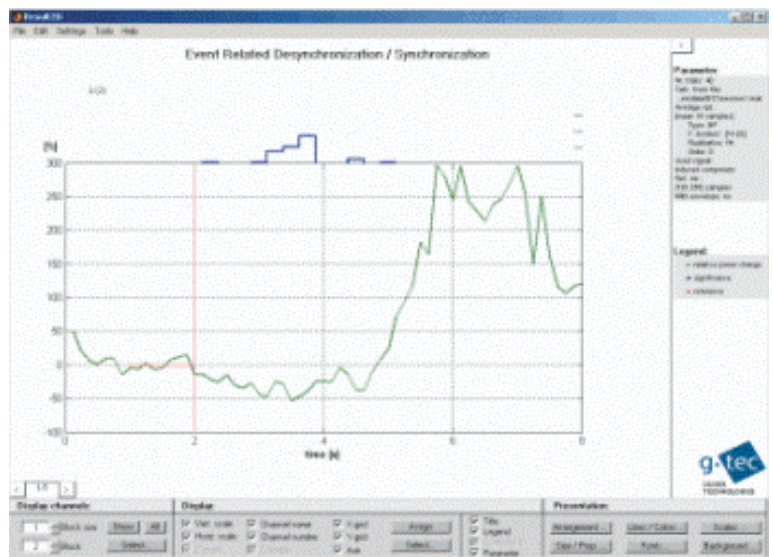

Quantification of ERD as function of time

The **second step** is to quantify ERD within the most reactive frequency bands as function of time. Hence one can observe time evolution of ERD over different brain areas.

Different options exist to express Event-Related Desynchronization and Event-Related Synchronization.

(i) ERD/ERS values can be expressed as absolute power values varying over time or

(ii) (ii) ERD/ERS values can be related to a so-called reference period. Then time varying ERD/ERS values are given in percentage values indicating the relative power decrease or increase with respect to the reference period.

The figure to the right displays percentage values of ERD/ERS over time. The reference period is indicated as a horizontal red line. After second 2, ERD values decrease to about -50%. Between second 5 and 8, an ERS can be observed, with a bandpower increase of up to 300 %.
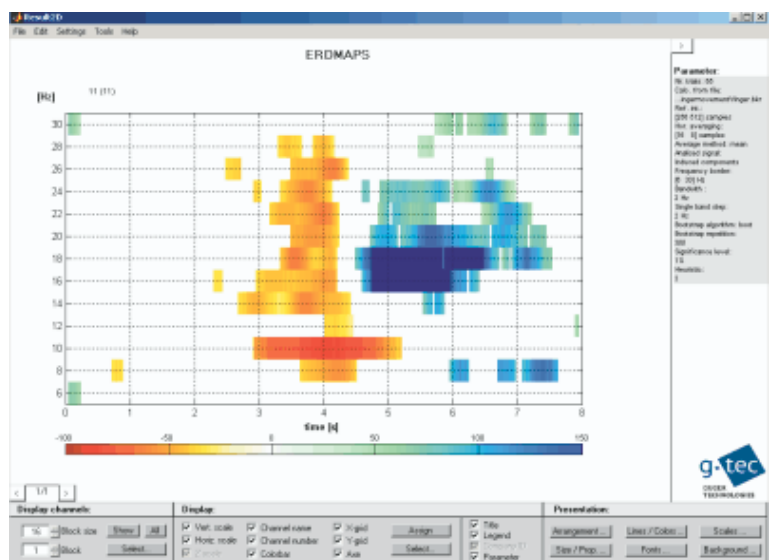
Time-frequency distribution of ERD/ERS

g.EEGtoolbox allows for a **third** option in calculating ERD/ERS: A novel time-frequency computation and representation allows you to conveniently identify the most reactive frequency bands and the related channels.

The analyze menu **ERDmaps** allows you to calculate ERD and ERS for multiple frequency bands and to present the results in a single colormap per channel.

ERDmaps can be calculated without any significance statistics (fast) or with a bootstrap algorithm. When using the bootstrap algorithm, it is possible to define a significance level. Then, ERD and ERS are only displayed if they are within the specific confidence range.

Example: Topographical Mapping of results

The result of spatio-temporal computations can be displayed in the 2D result presentation tool *g.Result2D*.

After defining the corresponding electrode montage for the EEG experiment in the montage creator *g.MONcreator*, including electrode co-ordinates and electrode names, computational results can be displayed topographically.

The figure to the right displays the average and standard deviation for a 60 channel ERD/ERS experiment.

Topographical plots of grand averages and standard deviations are very useful tools to discover artifacts in the data.

If technical artifacts (e.g. cross-talk of trigger channels) cannot be ruled out, then such artifacts can be detected and made visible by simple averaging across trials.