# Foundational lectures for engineering applications: from classical to advanced/novel digital signal analysis *Lecturer:*

*Prof. Len Gelman Cranfield University, UK*

**Short description of the lecture (up to 10 sentences):**

The lectures will describe the foundational classical and advanced digital signal analysis for engineering applications which is an important background for PhD students working in engineering areas (e.g. Electrical Engineering, Mechanical Engineering, Electronics and Informatics, etc.).

Lectures are starting with a transition from analogue to digital signals and are describing the main properties of digital signals and digital systems, signal and system classifications and properties, including stationarity, linearity, ergodicity and stability.

Lectures are continuing with a transition from the continuous Fourier transform via the Discrete Time Fourier transform to the foundational Discrete Fourier transform (DFT) and the Inverse Discrete Fourier transform and are describing the main properties of the DFT, including the aliasing in frequency domain and advanced usage of analogue and digital anti-aliasing filters.

Lectures are further continuing with a transition from the foundational classical non-parametric power spectral density (PSD) to the advanced parametric PSD (i.e. via advanced Yule-Walker method based on both the finite impulse response and the infinite impulse response models) and are describing the main properties of the PSD, including the frequency resolution properties on the background of noise, a leakage in the frequency domain and the time domain zero-padding.

Lectures are further continuing with a transition from the foundational classical digital filtering to the advanced adaptive digital filtering, including inverse filters and adaptive Wiener filters, and are describing various filter classifications, the main properties of digital filtering and the main techniques for design of the finite impulse response filters and the infinite impulse response filters, including the advanced commercially used computer aided design methods. Different types of filters (e.g. Bessel filters, Chebyshev filters, elliptic filters, etc.) are described and analysed.

The advanced usage of the DFT and the IDFT for digital filtering is also described, analysed and compared with the classical filtering via the convolution.

Lectures are further continuing with a transition from the foundational classical discrete time covariances to the radically novel discrete higher order nonlinear spectral covariances (proposed by L Gelman), including stationary and non-stationary

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nonlinear spectral covariances, and are describing properties of these covariances and the main methods for covariance estimation. The radically novel nonlinear spectral covariances are generalization of the classical higher order spectra.

Finally, the novel engineering applications and validation of these signal analysis techniques via simulation, laboratory and in-field testing will be also described..

**Syllabus of the lecture subjects (enlisted):**

1. Summary of the state-of-the-art

2. From the analogue signals and systems to the digital signals and systems

3. From the classical continuous Fourier transform to the discrete Fourier transform and the discrete inverse Fourier transform

4. From the classical non-parametric power spectral density to the advanced parametric power spectral density

5. From the classical digital filtering to the advanced adaptive direct and inverse digital filtering. Adaptive inverse Wiener filters.

6 Digital filtering methods by the discrete Fourier transform and the discrete inverse Fourier transform

7. From the classical digital time covariances to the radically novel higher order digital stationary and non-stationary (i.e. time-frequency) nonlinear spectral covariances

8. Validation of the techniques by numerical simulation

9. Validation of the techniques by laboratory experiments

10. Validation of the techniques by in-field trials

11. Industrial engineering applications of the techniques

| Terminy wykładów | | | |
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| **Data** | **Dzień tyg.** | **Godzina** | **Sala** |
| 2015-12-16 | Śr | 9.15-14.00 | EA E28 |
| 2015-12-17 | Cz | 9.15-14.00 | EA E28 |
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