**SiSy**

**Content Overview**

**Chapter 1 Introduction**

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| **Signals:** time functions, measurements | |
| Properties | * analog / digital * periodic / aperiodic * power / energy * even / odd |
| **Systems:** processes with input and output signals | |
| Properties | LTI   * linearity * time invariance * causality |
| **Test Signals:** | |
| Continuous | * step * impulse * cos, sin, exp(j.alpha) |
| Discrete | * step * impulse * cos, … |
| Obs. | Relationship step vs. Impulse |
| **Operation with time variable** | |
|  | * time-shift * time-scaling * mirrowing * Convolution * Correlation |
| **Exercises** | |
|  | Exer1 ; Lab1A, 1B, 1C ; Test1 |

**Chapter 2 Periodic Signals (Fourier Series)**

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| **Spectrum Introduction** | |
|  | * Cosine wave as single-sided and double-sided spectrum |
| **Fourier Series** | |
|  | Fourierreihe (FR)   * Enables representation periodic signals in freq domain * Analysis (Zerlegung) ; Synthesis (sum-up harmonics) |
| Notations | 1. Real ak, bk : cartesian, even/odd parts 2. Real Ak, phik: polar; single-sided spectrum 3. Complex ck: amp+phase; double-sided spectrum   Relationship among notations |
| **Reference Signal :**  periodic square | |
|  | * With 50% duty cycle : only odd harmonics * Generic with tau/T0 duty cycle : ck = A.tau/T0.sinc(k.pi.tau/T0) |
| Obs. | Sinc Function : form, sinc(0)=1 ; zero-crossings |
| **FR Properties** | |
|  | * Discrete, line-spectrum * Symmetry for double-sided spectrum * DC-Value/Offset ; Time-Shift ; Parseval |
| **Numerical Approx with DFT (FFT)** | |
|  | ck ~ X[k]   * Time Window (N.Ts) ; Spectrum Range [0, Fs) * Parameters of X[k] : N-Points ; Fs = 1/Ts ; fstep = 1/(N.Ts) * Limitations of X[k] : resolution, aliasing |
| **Exercises** | |
|  | Exer2 (FR) ; Exer3 (DFT) ;  Lab2A, 2B, 2C |

**Chapter 3 Fourier Transformation (FT)**

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| **Transition FR => FT** | | |
|  | * Transition from periodic to non-periodic signals:   period tends to infinite, line-spectrum tends to continuous spectrum   * Lim (T0.ck) => X(f) | |
| **Definition of FT and IFT** | | |
|  | * Connect pair of functions: x(t) ⬄ X(f) * X(f) is complex function,  representation double-sided amp + phase spectrum * X(f) calculation   + with integral for non-periodic & energy signals   + with properties for periodic & power signals * Examples :   + Non-periodic square pulse ; decay exp ; dirac   + Step (integral property), cos (freq-shift property) | |
| **Properties «Catalog » and Examples** | | |
|  | * Time-bandwidth product (ex. vary width square pulse); * Duality (ex. : dirac in time and freq domain); * Frequency-Shift (ex. Modulation); * Derivation (G(ω) from diff.equation), * Convolution-vs-multiplication (vide comb function below) ; * … | |
| **FT for Periodic Signals** | | |
|  | * Discrete Spectrum with dirac impulses * Same harmonics as in FR double-sided spectrum, with ck value as weight for the dirac impulses | |
| **FT for Time Discrete Signals** | | |
|  | * Periodic Spectrum with original plus image spectra * Image spectra around multiples of Fs * Aliasing effect and anti-aliasing filter | |
| **Comb Function in time and freq domain** | | |
|  | p(t) ⬄ P(f) both are comb functions   * convolution in time domain with p(t)   + goes from aperiodic to periodic time fct   + spectrum changes from continuous to discrete * multiplication in time domain with p(t) (ideal sampling)   + goes from continuous to discrete time fct   + spectrum changes from aperiodic to periodic | |
| **How does the DFT works** | | |
|  | * estimates spectrum of a periodic and discrete time function. * Resulting spectrum is therefore discrete and periodic * Only the range 0-Fs is calculated | |
| **Relationship signal representation in Time and Freq Domain** | | |
| **Time Domain** | | **Frequency Domain** |
| periodic | | discrete |
| discrete (sampled) | | periodic |
| non-periodic | | continuous |
| continuous | | non-periodic |
| **Exercises** | | |
|  | Exer4 (FT) ; Lab3A & 3B (FT properties) | |

**Chapter 4 AD-DA Conversion**

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| **Ideal Sampling** | |
| ADC | * Multiplication with comb function in time domain |
| **Aliasing Effect** | |
| ADC | * Sampling theorem * Alias effect visualisation in time and frequency domain * Image spectrum; periodic spectrum (after sampling);  spectrum mirrowed by Fs/2 (after sampling) * Anti-alias filter (AAF) |
| Obs | Other effects affecting ADC:   * Resolution (number of bits and quantisation error) * Jitter effect (variation of the sampling period) |
| **Reconstruction** | |
| DAC | * Using Zero-Order-Holder (ZOH) and post-filter shapes in time and frequency domain |
| **Exercises** | |
|  | Exer5 ; Lab4 |

**Chapter 5-6-7 Systems**

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| **System Modelling** time functions, measurements | |
| Analytical  (transparent box) | Use physical rules to get for:   * continuous system : Differential Equation   (can do BSB plus simulate) * discrete system: Difference Equation |
| Empirical  (black box) | Use measurement with test signals to get for:   * continuous system : step, impulse and frequency responses * discrete system: step, impulse and frequency responses |
| **Convolution with Impulse Response** | |
|  | Convolution (« Faltung » or « ta-chaco-zum »)   * operation convolution (how it works) * conv with imp-resp : calculate system response for any input signal (for both continuous and discrete systems) |
| **Frequency Response** | |
|  | Also called transfer function (with s) (german « Frequenzgang »)   * complex function G(jω) = G(ω) = G(f) * polar notation  (amplitude & phase) * calculation from diff. equation (with exp(jω) or learned later that it is easier and faster with FT derivation property) * for cos input signal G(ω) represents change in amp and phase * Bode diagram (dB, asymptotes and corner points) |
| **Reference Systems** | |
|  | * Types: 1st order (LPF, HPF) and 2nd order (LPF) * Views: DGl, BSB, step-resp, imp-resp, G(jω) * Parameters: 1st order (k, tau ), 2nd order(k, ω0, d) * Examples: 1st order(RC passive), 2nd order (Pendel, RLC) |
| **Exercises** | |
|  | Exer6 (DiffEqu + BSB) ; Exer7 (Convolution) ; Exer8 (G(jω)) ; Exer9 (Ref.Sys) , Test2 ,  Lab5 (Pendulum) ; Lab6A & 6B (G(jω) and Conv) , Lab7 (filter) |