System Identification - A Frequency Domain Approach, 2nd edition

Errata list

PAGE	LINE or EQ.	IN BOOK	SHOULD BE
54	(2-50)	$\hat{\sigma}^2_{\hat{G}}(k) \approx$	$(M-1)\hat{\sigma}^2_{\hat{G}}(k) \approx$
56	(2-57)	$G_0(j\omega_k)(N_1(k) - N_2(k))$	$G_0(j\omega_k)(1 + N_1(k) - N_2(k))$
59	line -14	DTF	DFT
110	1st line of (3-77)	$g_\alpha(\tau_0, ..., \tau_{\alpha-1})u(t-\tau_0)...u(t-\tau_{\alpha-1})$	$g_\alpha(\tau_1, ..., \tau_\alpha)u(t-\tau_1)...u(t-\tau_\alpha)$
146	-6	$(M = TF_0/(2P))$	$(M = Tf_0/(2P))$
163	5	… w.r.t. for increasing …	… w.r.t. ϕ for increasing …
185	2nd line after (6-33)	… $\max(n_a, n_b) - 1$ …	… $\max(n_a, n_b) - 1$ for $\Omega = z^{-1}$ and $n_i = \max(n_a, n_b)$ for $\Omega = s, \sqrt{s}$ …
188	1st line before Section 6.3.3	… $n_i \geq \max(n_a, n_b) - 1$.	… $n_i > \max(n_a, n_b) - 1$. (proof: see Note a)
189	2nd line before Section 6.3.4	… $\geq \max(n_a, n_b) - 1$.	… $> \max(n_a, n_b) - 1$. (proof: see Note a)
190	line 3	… $\geq \max(n_a, n_b) - 1$.	… $> \max(n_a, n_b) - 1$. (proof: see Note a)
199	1st line after (6-66)	… $n_i = (\max(n_c, n_d) - 1)$ …	… $n_i = \max(n_c, n_d) - 1$ for $\Omega = z^{-1}$ and $n_i = \max(n_c, n_d)$ for $\Omega = s, \sqrt{s}$ …
199	line -3	$n_j = \max(n_c, n_d) - 1$	n_j
208	(6-99)	$X(k) = \frac{1}{T_s\sqrt{N}} \sum_{n=-\infty}^{+\infty} X_N(s_k - nj\omega_s)$	$X(k) = \frac{1}{T_s\sqrt{N}} \sum_{n=-\infty}^{+\infty} X_N(s_k - nj\omega_s) - \frac{x(NT_s) - x(0)}{2\sqrt{N}}$ (proof: see Note a)

PAGE	LINE or EQ.	IN BOOK	SHOULD BE
208	1st line after (6-100)	$I(s) = \frac{I_1(s) - I_2(s)}{\sqrt{N}T_s}$ is a polynomial of order $\max(n_a, n_b) - 1$	add the follow terms to $I(s)$ $B(s)\frac{u(NT_s) - u(0)}{2\sqrt{N}} - \dots$ $A(s)\frac{y(NT_s) - y(0)}{2\sqrt{N}}$ and replace "$\max(n_a, n_b) - 1$" by "$\max(n_a, n_b)$" (proof: see Note a)
240	(7-48)	$G_{rz}(\Omega_k) = \begin{bmatrix} G_{ry}(\Omega_k) \\ G_{ry}(\Omega_k) \end{bmatrix}$	$G_{rz}(\Omega_k) = \begin{bmatrix} G_{ry}(\Omega_k) \\ G_{ru}(\Omega_k) \end{bmatrix}$
253	-13	Examples of such signals are one column of the Hadamard or orthogonal multisines of Section 2.7.2 on page 65, where $r_{\text{siso}}(t)$ is a random phase multisine, or one column of the (full) random orthogonal multisines of Section 3.7 on page 92.	Examples of such signals are n_u different realizations of a random phase multisine, or one column of the (full) random orthogonal multisines of Section 3.7 on page 92.
270	(7-113)	$E\{ V_{n[j,:]}^H \; V_{n[i,:]} \}$	$\mathbb{E}\{ V_{n[j,:]}^H \; V_{n[i,:]} \}$
273	(7-134)	$\Delta\hat{G}_{ru}$	$\Delta\hat{G}_{rz}$
281	5	… constraint optimization …	… constrained optimization …
425	line after (10-119)	the sum of $F(z^{-1})$ over can …	the sum of $F(z_k^{-1})$ over k can …
448	-12	… for models …	… for s- domain models …
449	caption Figure 11-8	… measure-ment …	… measurement …
529	-19	… can be sued for …	… can be used for …

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Note a: Relationship between the DFT and the Continuous Fourier Spectrum

Consider a continuous-time signal $x(t)$ sampled at the rate $f_s = 1/T_s$ and observed during $T = NT_s$ (see Fig. 1). Using the notation on p. 39, the relationship between the DFT $X_{\mathrm{DFT}}(k)$ of the observed samples $x(nT_s)$, $n = 0, 1, \ldots, N-1$,

$$X_{\mathrm{DFT}}(k) = \sum_{n=0}^{N-1} x(nT_s)e^{-j2\pi nk/N} \qquad \text{(E-1)}$$

and the continuous Fourier spectrum $X_T(j\omega) = F\{x(t)w_T(t)\}$, with $w_T(t) = 1$ for $t \in [0, T]$ and zero elsewhere, is given by

$$X_{\mathrm{DFT}}(k) + (x(NT_s) - x(0))/2 = \frac{1}{T_s}\sum_{n=-\infty}^{+\infty} X_T(j(\omega_k - n\omega_s)) \qquad \text{(E-2)}$$

where $\omega_k = 2\pi k f_s/N$.

Proof: The relationship between the Fourier spectrum $X(e^{j\omega T_s})$ of the discrete-time samples $x(nT_s)$, $n \in \mathbb{Z}$,

$$X(e^{j\omega T_s}) = F\left\{\sum_{n=-\infty}^{+\infty} x(t)\delta(t - nT_s)\right\} = \sum_{n=-\infty}^{+\infty} x(nT_s)e^{-nj\omega T_s} \qquad \text{(E-3)}$$

and the Fourier spectrum $X(j\omega) = F\{x(t)\}$ of the continuous-time signal $x(t)$ is given by

$$X(e^{j\omega T_s}) = \frac{1}{T_s}\sum_{n=-\infty}^{+\infty} X(j(\omega - n\omega_s)) \qquad \text{(E-4)}$$

(see pp. 82-83 of A.V. Oppenheim and R.W. Schafer (1989). *Discrete-Time Signal Processing.* Englewood Cliffs (NJ)).

While (E-4) remains valid for the windowed signal $x(t)w_T(t)$

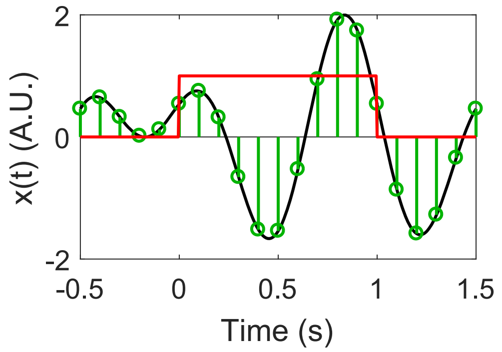

Figure 1. Continuous-time signal $x(t)$ (black line) sampled at the rate f_s (green circles) and observed during $T = 1$ s (red rectangular window).

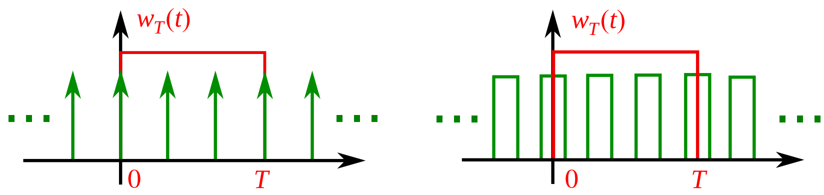

Figure 2. Dirac train $\sum_{n=-\infty}^{+\infty}\delta(t-nT_s)$ (left) and train of block functions $\sum_{n=-\infty}^{+\infty}\delta_{T_0}(t-nT_s)$ (right), where $\delta_{T_0(t)}$ is defined in Fig. 3. At the edges of the observation window $w_T(t)$ the block function is halved.

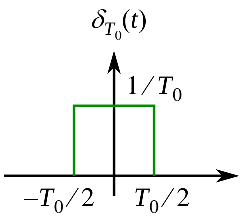

Figure 3. Block function $\delta_{T_0}(t)$.

$$X_T(e^{j\omega T_s}) = \frac{1}{T_s}\sum_{n=-\infty}^{+\infty} X_T(j(\omega-n\omega_s)) \tag{E-5}$$

this is no longer true for the right hand side of (E-3) because the Dirac functions at the edges of the window $w_T(t)$ are multiplied by a discontinuity (see Fig. 2, left plot). To quantify the result of the multiplication of a Dirac function with a discontinuity in the Fourier spectrum

$$X_T(e^{j\omega T_s}) = F\left\{\sum_{n=-\infty}^{+\infty} x(t)w_T(t)\delta(t-nT_s)\right\} \tag{E-6}$$

we replace the Dirac function $\delta(t)$ by the block function $\delta_{T_0}(t)$ defined in Fig. 3 and take the limit for $T_0 \to 0$

$$X_T(e^{j\omega T_s}) = \lim_{T_0\to 0} F\left\{\sum_{n=-\infty}^{+\infty} x(t)w_T(t)\delta_{T_0}(t-nT_s)\right\} \tag{E-7}$$

From the right plot of Fig. 2 it can be seen that half of the area of the block functions $\delta_{T_0}(t)$ and $\delta_{T_0}(t-T)$ is cut away by the window $w_T(t)$. Therefore,

$$\int_{-\infty}^{+\infty}\delta_{T_0}(t)w_T(t)dt = \int_{-\infty}^{+\infty}\delta_{T_0}(t-T)w_T(t)dt = \frac{1}{2} \tag{E-8}$$

and, hence, the samples $x(0)$ and $x(NT_s)$ only contribute with a factor 1/2 to the spectrum (E-7)

$$X_T(e^{j\omega T_s}) = \lim_{T_0\to 0} F\left\{\sum_{n=-\infty}^{+\infty} x(t)w_T(t)\delta_{T_0}(t-nT_s)\right\} = \frac{x(0)}{2} + \sum_{n=1}^{N-1} x(nT_s)e^{-nj\omega T_s} + \frac{x(NT_s)}{2}e^{-Nj\omega T_s} \tag{E-9}$$

Note that this result is consistent with the property that the inverse Fourier transform of $X_T(j\omega)$ evaluated at $t = 0$ and $t = NT_s = T$ gives, respectively, $x(0)/2$ and $x(T)/2$. Combining (E-1) with (E-5) and (E-9) evaluated at $\omega = \omega_k = 2\pi k f_s/N$ proves (E-2).

Discussion: The consequence of (E-2) is that Eq. (6-99) on p. 208 should be replaced by

$$X(k) = \frac{1}{\sqrt{N}} \sum_{t=0}^{N-1} x(tT_s) z_k^{-t} = \frac{1}{T_s \sqrt{N}} \sum_{n=-\infty}^{+\infty} X_N(s_k - nj\omega_s) - \frac{x(NT_s) - x(0)}{2\sqrt{N}} \tag{E-10}$$

and that the following terms should be added to $I(s_k)$ in Eq. (6-100)

$$B(s_k)\frac{u(NT_s) - u(0)}{2\sqrt{N}} - A(s_k)\frac{y(NT_s) - y(0)}{2\sqrt{N}} \tag{E-11}$$

Hence, $I(s)$ is a polynomial of order $\max(n_a, n_b)$ instead of $\max(n_a, n_b) - 1$.

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Errors in figures

page 55, Figure 2-20 should be replaced by

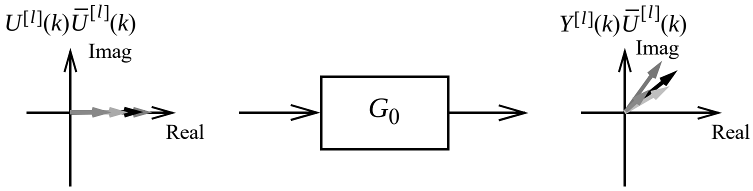

Figure 2-20. Successive realizations of $U^{[l]}(k)\bar{U}^{[l]}(k)$ and $Y^{[l]}(k)\bar{U}^{[l]}(k)$.

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