Errata, Corrigenda, and Clarifications
Wireless Communications, 2nd edition, by A. F. Molisch
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While I made great effort to ensure a high quality of this book, no claim is made by me (or the publisher) that the information in the book is error-free or complete. As a matter of fact, a tome like this almost inevitably contains errors, and the current document is an attempt to share with the readers corrections to the typos, misprints, and errors that author and readers of the book have discovered. If you find any errors, please email them to molisch@usc.edu.

Andy Molisch, November 1st, 2010.

Special thanks to Dr.. Arjan Meijerink for his many detailed comments.

- p. 39, Fig. 3.1: label on the y axis: "Noise Figure" should be replaced by "Excess noise", and F_0 means the measured environmental noise power
- p. 39, above Eq. (3.6): the words "noise figure" should be replaced by "noise factor" when discussing ratio of input to output noise on a linear scale; the noise factor expressed in dB is called noise figure. It is assumed implicitly here that the temperature is the room temperature, in which case the noise factor is also called "standard noise factor".
- p. 39, under eq. 36. The sentence Note that.. should be replaced with The noise figure of passive components equals their loss (on a dB scale).
- p. 50, Fig. 4.1: Add in the caption: "For the TE case the E vectors point into the page, and for the TM case the H vectors point out of the page."
- p. 53, third line: "reflected" should be replaced by "transmitted"
- p. 53, Eq. (4.25): the left hand side should be replaced by $d_{\mathrm{break}'} = ...$
- p. 53, 3 lines below Eq. (4.25). sentence should read "....for distances below $d_{\mathrm{break}'}$
- p. 53, last paragraph: after the words ".... until a breakpoint d_{break} " add "(note that $d_{\mathrm{break}'}$ is different from $d_{\mathrm{break}'}$ - $d_{\mathrm{break}'}$ is defined via the phase difference between direct and ground-reflected wave, while d_{break} is defined via the intersection of the curve fits to d^2 and d^4).
- Eq. (4.30): note that this equation requires that d_{TX}, $d_{RX} >> h, \lambda$
- p. 55, first line under Fig. 4.4 replace "..any point to the right of the screen ($x > 0$)..." with "..any point in the far field ($x >> \lambda$)..."
- p. 55, second line under Fig. 4.4: "the incident field" should be replaced by "the field that would be obtained if the screen were not there."
- p. 56, line 1: replace $\nu_{\mathrm{F}} = -2y/\sqrt{\lambda x}$ by $\nu_{\mathrm{F}} = -y\sqrt{2/(\lambda x)}$
- p. 56: Fig. 4.5: strike the upper two subfigures, which relate incorrectly normalized versions of Fresnel integrals
- p. 65, second line above 4.4.2: The Rayleigh roughness is $k_0 * \sigma_h * sin(\psi)$, (i.e., strike the "2" in the book)
- p. 79: Eq. (5.15) add "for $-\pi < \psi \leq \pi$
- p. 82, line 8: replace the words "in order to ensure successful communication in x % of the situation" with "in order to ensure that communications fail in no more than x % of the situations".
- p. 82, Eq. (5.24) and (5.25): add "for $r \geq 0$
- p. 83, Eq. (5.26) add "for $r \geq 0$ and $-\pi < \psi \leq \pi$"

- p. 85, first line of Eq. (5.30): replace $0 \leq r < \inf$ by $0 \leq r_{\min} < \inf$
- p. 86, Eq. (5.33) add "for $-\pi < \psi \leq \pi$"
- p. 86, after Eq. (5.34) add "The modified Bessel function of the first kind and order n is given by $I_n(x) = \frac{1}{2\pi}\int_0^{2\pi} exp(xcos\theta)cos(n\theta)d\theta$ where n is integer.
- p. 87, Eq. (5.35): add "for $r \geq 0$
- p. 87, after Eq. (5.35) add "where Euler's Gamma function is defined as $\Gamma(x) = \int_0^{\inf} t^{x-1}exp(-t)dt$ which for integer values of x reduces to $\Gamma(x) = (x-1)!$
- p. 87, Eq. (5.36) should be replaced by

$$m = \frac{\overline{\Omega}^2}{\left(r^2 - \overline{\Omega}\right)^2}. \tag{1}$$

- p. 87 Eq. (5.37) add "for $P \geq 0$"
- p. 88 replace "while" by "or conversely"
- p. 88/89 : replace The received power spectrum as a function of the direction is thus

$$S(\gamma) = \overline{\Omega}\left[pdf_\gamma(\gamma)G(\gamma) + pdf_\gamma(-\gamma)G(-\gamma)\right] \tag{2}$$

where $\overline{\Omega}$ is the mean power of the arriving field. In Eq. (4), we have also exploited the fact that waves from the direction γ and $-\gamma$ lead to the same Doppler shift, and thus need not be distinguished for the purpose of deriving a Doppler spectrum.

In a final step, we have to perform the variable transformation $\gamma \longrightarrow \nu$. The Jacobian can be determined as

$$|\frac{d\gamma}{d\nu}| = |\frac{1}{\frac{d\nu}{d\gamma}}| = \frac{1}{|\frac{\mathrm{v}}{c_0} f_\mathrm{c}\sin(\gamma)|} = \frac{1}{\sqrt{\left(f_\mathrm{c}\frac{\mathrm{v}}{c_0}\right)^2 - (f - f_\mathrm{c})^2}} = \frac{1}{\sqrt{\nu_{\max}^2 - \nu^2}} \tag{3}$$

so that the Doppler spectrum becomes

by

The received power spectrum as a function of the direction is thus

$$S(\gamma) = \overline{\Omega}\left[pdf_\gamma(\gamma)G(\gamma)\right] \tag{4}$$

where $\overline{\Omega}$ is the mean power of the arriving field that would be received with an omni-antenna.

In a final step, we have to perform the variable transformation $\gamma \longrightarrow \nu$. The Jacobian can be determined as

$$|\frac{d\gamma}{d\nu}| = |\frac{1}{\frac{d\nu}{d\gamma}}| = \frac{1}{|\frac{\mathrm{v}}{c_0} f_\mathrm{c}\sin(\gamma)|} = \frac{1}{\sqrt{\left(f_\mathrm{c}\frac{\mathrm{v}}{c_0}\right)^2 - (f - f_\mathrm{c})^2}} = \frac{1}{\sqrt{\nu_{\max}^2 - \nu^2}} \text{for } -\nu_{\max} \leq \nu \leq \nu_{\max} \tag{5}$$

We furthermore have to take into account the fact that waves from the direction γ and $-\gamma$ lead to the same Doppler shift, and thus need not be distinguished for the purpose of deriving a Doppler spectrum. The Doppler spectrum thus becomes...

- p. 89, Eq. (5.45): add "for $-\nu_{\max} \leq \gamma \leq nu_{\max}$"
- p. 89, 3 lines under (5.45): replace "vertical dipole" by "vertical Hertzian dipole"

- p. 89, Eq. (5.46): add "for $-\pi < \nu \leq \pi$"
- p. 90, before Eq. (5.48) insert the word "approximately" after "is thus"
- p. 90, Eq. (5.48): denominator $\overline{r(t)^2}$ should be replaced by $\overline{r(t)^2} - \overline{r(t)}^2$
- p. 90, example 5.3. Insert before "As a first step..." the sentence "The temporal correlation function when traveling at a speed v through a static environment is completely equivalent to the spatial autocorrelation function with (spatial) displacement $v\Delta t$.
- p. 92, Eq. (5.50): insert "for $r \geq 0$."
- p. 93, Eq. (5.51): insert "for $r \geq 0$. "
- p. 94, second paragraph of Sec. 5.73: replace "The pdf of the instantaneous frequency" by "The pdf of the instantaneous angular frequency"
- p. 94, Fig. 5.27a: label of y-axis: replace $\sqrt{2}\nu_{\max}$pdf by $2\pi\sqrt{2}\nu_{\max}$pdf
- p. 95, Eq. (5.58): "for $F \geq 0$. "
- p. 95, Eq. (5.59): left hand side should read $pdf_P(P)$. Furthermore, add after the equation "for $P \geq 0$. "
- p. 95, end of last-but-one paragraph: add the sentence: "Also note that the product of lognormal random variables is exactly lognormally distributed.
- p. 96, 2 lines above Eq. 5.60: at the end of the line add "(compare Eq. 5.17)".
- p. 96, Eq. (5.60): insert ""for $r \geq 0$."
- p. 96, Eq. (5.61): replace $2 \cdot 10 ln(10)$ by $20/ln(10)$. At the end of the equation, add "for $r \geq 0$."
- p. 96, end of paragraph under Eq. (5.61): add "Note, however, that the relationship between μ_{dB} and $\mu_{\mathrm{P,dB}}$ is different when the small-scale statistics are not Rayleigh.
- p. 96, Eq. (5.62): insert ""for $P \geq 0$."
- App. 5.C, Eq. (5.82): replace $\Omega_0 = 3\frac{E_0^2}{4}$ by $\Omega_0 = 3\frac{\overline{\Omega}}{2}$
- App. 5C, Eq. (5.83): Note that for the Jakes spectrum (and generally for $\Omega_1 = 0$), r and $\dot{r}$ are independent. Thus the level crossing rate becomes $\frac{1}{2}pdf(r)E|\dot{r}|$. This is an intuitively appealing result: the most likely values get crossed the most often (according to a Rayleigh distribution), and the higher the average absolute value of the derivative of $r(t)$, the more often crossings occur. For the Jakes spectrum we find $E|\dot{r}| = \sqrt{2\Omega_2/\pi} = \sqrt{2\pi}\nu_{\max} r_{\mathrm{rms}}$
- p. 102, before Eq. (6.2) insert the words "(in complex baseband representation, compare also Sec. 11.2, Eq. (11.1))"
- p. 105, Fig. 6.4: add in the caption: $h_s(\tau)$ describes the "system impulse response", incorporating their "fundamental pulse shape" that we wish to transmit, as well as the effects of filters etc.
- p. 110, 4 lines below Eq. (6.21): replace "Doppler spectrum" by "temporal autocorrelation function"
- p. 110, 3 lines above Eq. (6.22): replace "independent" by "uncorrelated"
- p. 110, Eq. (6.22): replace dt' by $d\Delta t$
- p. 113, last-but-one line: insert "for $\tau > 0$" before the words "is physically possible"
- p. 115, after Eq. (6.46), insert: "Since $R_H(0, \Delta f)$ is the Fourier transform of a real function (the PDP), it is Hermitian symmetric, and its absolute value is an even function of f. Thus we can simplify the above to
$$B_{\mathrm{coh}} = \arg\max_{\Delta f > 0}\left(\frac{R_H(0,\Delta f)}{R_H(0,0)} = 0.5\right) \tag{6}$$

- p. 117, Fig. 6.9. Add in the caption: the exact relationships for going from the first to the second column are given in Eqs. (6.29-6.32)
- p. 121, at end of second line insert "Note that Ω and Ψ are spatial angles, describing both azimuth and elevation.
- p. 121 Eq. (6.57): replace "APDS" by "ADPS"
- p. 147, two lines above Eq. (8.5) replace "twice" by "at least twice"
- p. 148, first sentence after Eq. 8.9: should be eliminated. Explanation: the two-dimensional Nyquist criterion generally refers to sampling in the time/frequency plane that is sufficiently fast to completely describe the time-variant impulse responses. Eq. (8.9) gives a criterion such that the two-dimensional Nyquist criterion *can* be fulfilled, but it is not the criterion itself.
- p.149, end of Example 8.1, replace,"...of the sounding pulse should be increased;" by ... of the sounding pulse should be decreased
- p. 160, second sentence of Sec. 8.5.2: replace by "The phase resolution of the array is determined by the size of the array, approximately $2\pi/N_{\mathrm{r}}$. The corresponding angular resolution for large N_{r} is $\lambda/(N_{\mathrm{r}}d_{\mathrm{a}})$.
- p. 165-168: Secs. "Efficiency" and "directivity" should be interchanged.
- p. 166, end of "directivity" subsection. Replace the last sentence with: "Note that in the literature the terms "gain" and "directivity" are often treated synonymously; something we have partly done in the preceding equations (using the symbol G for directivity), and will do in the remainder of the book as well.
- p. 189, second line: replace "power" by "energy"
- p. 189, line after Eq. 11.4): add a footnote at the end of the sentence: "Note that some books define $sinc(x) = sin(\pi x)/(\pi x)$."
- p. 190, line after Eq. (11.5) add a footnote after the word "spectrum": "This is a spectrum in the sense of the Fourier transform of the signal. The *energy* spectrum is the squared magnitude."
- p. 194, line above Eq. (11.20) and above (11.21): replace "power spectrum" by "energy spectrum"
- p. 195, first line of third paragraph: replace "orthogonal" by "orthonormal"
- p. 196, Eq. (11.29): the numerator is an inner product between the two vectors
- p. 196, line above Eq. (11.31): replace "vector" by "function"
- , p. 196, after Eq. (11.31): Add: "Note that the use of 1 and j as distinct expansion functions is meaningful only be used when the expansion coefficients are constrained to be real"; if we admit complex coefficients, then a single expansion function $\sqrt{1/T_s}$ should be used.
- p. 197, Eq. (11.34): replace $b_i * g(t)$ by $[b_i\delta(t - iT_{\mathrm{s}})] * g(t))$
- p. 196, Eq. (11.32): replace $||s_{\mathrm{LP},m}(t)||^2$ by $|s_{\mathrm{LP},m}(t)|^2$
- p. 198, Eq. (11.39): replace by

$$\widetilde{b}_i = b_i\widetilde{b_{i-1}} \tag{7}$$

- p. 199, after the first sentence, insert the sentence: "An estimate of the $i-th$ bit is obtained as $\widetilde{b}_i\widetilde{b_{i-1}}$."
- p. 201: Fig.s 11.12 and 11.13 should be interchanged.
- p. 201, last paragraph of Sec. 11.3.2: The reference to Fig. 11.16 should be replaced by a reference to Fig. 11.17

- p. 201, last sentence of Sec. 11.3.2: strike "(Figure 11.17)"
- p. 203: Above (11.46), "subsequent signal constellations" should be replaced by "subsequent signal constellation points", and the reference to Fig. 11.19 should be replaced by a reference to Fig. 11.21. Below (11.46) the reference to Fig. 11.20 should be replaced by a reference to Fig. 11.19, and on p. 204 the reference to Fig. 11.21 should be replaced by a reference to Fig. 11.20.
- p. 208, Eq. (11.48) replace by

$$s_{\mathrm{BP}}(t) = \sum_i \sqrt{2E_{\mathrm{S}}/T_{\mathrm{S}}} \cos\left(2\pi f_{\mathrm{c}} t + \frac{2\pi}{M}(c_i - 1)\right) g(t - iT_{\mathrm{s}}) \quad c_i \text{element} 1, 2, ...M \tag{8}$$

- p. 208, Eq. (11.49) replace by

$$s_{\mathrm{LP}}(t) = \sum_i \sqrt{2E_{\mathrm{S}}/T_{\mathrm{S}}} \cos\left(j\frac{2\pi}{M}(c_i - 1)\right) g(t - iT_{\mathrm{s}}) \tag{9}$$

- p. 208, (11.51) add "for $0 \leq t \leq T$.
- p. 215, (11.69): T should be replaced by T_B. Add after the equation: "where the Gaussian basis pulses are given by (11.17)."
- p. 222, end of paragraph after Eq. (12.4). add ", since $S_{\mathrm{n,LP}}(f)$ is an even function."
- p. 222, last line, just above (12.6): This should be replaced by "In other words, which symbol m maximizes:"
- p. 226, (12.27): The r.h.s. should be replaced by $2Q(x\sqrt{2})$
- p. 229, second paragraph, fourth line: The equation should be replaced by $\sqrt{E_{\mathrm{B}}}(\pm 1, \pm j)$
- p. 229, just above (12.35): The equation should be replaced by $1 - [1 - Q(\sqrt{2\gamma_B})]^2$
- Eq. (12.37): the r.h.s. should read

$$\frac{1}{2} \exp\left(-\gamma_{\mathrm{b}}/2\right) \tag{10}$$

- p. 231, third line: replace "the outputs of the "absolute value" operation of the I- and Q-branches are then added up before the "select largest" operation" by "the squared outputs of the "absolute value" operation of the I- and Q-branches are then added up (and possibly the square root of the sum is taken) before the "select largest" operation"
- p. 231, two lines above Eq. (12.42): replace "the BER can be computed" by "for binary signals the BER can be computed"
- p. 231, line below Eq. (12.42): add "in this case the BER is $1/2exp(-\gamma_b/2)$.
- p. 232, first line: The reference to (12.37) should be replaced by (12.31).
- p. 238, Section 12.2.3, third line under third bullet: "many-scale" should be replaced by "many small-scale".
- second line from bottom: $f_{\mathrm{inst}} f_{\mathrm{mod}})$ should be replaced by $f_{\mathrm{inst}} + f_{\mathrm{mod}}$
- Example 16.1: Eq. (16.22) should read

$$E_2(z) = \frac{F^*(1/z)}{F(z)F^*(1/z) + N_0} = \frac{0.4 - 0.7z + 0.6z^2}{0.24z^2 - 0.7x + 1.31 - 0.7z^{-1} + 0.24z^{-2}} \tag{11}$$

  The subsequent expressions for the MSE are correct

- p. 420, third sentence of Sec. 19.4: replace "... on the performance of OFDM we convert..." by "...on the performance of OFDM: since we convert the system into a parallel system of narrowband channels, the symbol duration on each carrier is made much larger than the delay spread."

- p. 473: Fig. 20.14: legend (labels) should read: "without CSIT" (instead of "uniform") and "with CSIT" (instead of "water filling")

- Part V "Standardized systems" starts with Chapter 24 (not chapter 21). Consequently, the introduction to Part V (pp. 499-500) should be after p. 585.

- p. 505, first line of Sec. 21.3: replace "In an overlay system...." with "In an interweaving system....."

- p. 515, line 6: Rather, the better the channel between primary TX and secondary RX, the sooner the RX can decode should read Rather, the better the channel between primary TX and secondary TX, the sooner the secondary TX can decode

- p. 524 (Nonorthogonal Diversity xF),the text is "the source sends differently encoded information..." should be replaced by "the relay sends differently encoded information..."

- p. 526 (Transmission from te relay using repetition coding): Replace "Consequently, the source can add up..." with "Consequently, the destination can add up...."

- p. 527, 8th line below Eq.(22.6), replace "the source-relay or the relay-destination link provides..." by "the source-destination or the relay-destination link provides..."

- Eq. (23.3) should read

$$G_T = \frac{\frac{1}{N}\sum_{i=0}^{N-1}\sigma_{y_i}^2}{(\prod_{i=0}^{N-1}\sigma_{y_i}^2)^{1/N}} \tag{12}$$

- p. 781 Exercise 30.20.2 should specify that the antenna array is a uniform linear array with lambda/2 spacing

- p. 783, last equation exercise 7: first line: the argument of the Gamma function should read $\Gamma(N, \theta/2)$

- Fig. 30.14: connection from node 7 to 12 should have weight 9

- p. 757, Problem 30.6.3: "stationary" should be replaced by "static". The second case for the PDP should read $a_2 exp[(55.10^{-6} - \tau)b_2]$

- p. 765, Exercise 30.12.9: replace "with noise figures of 9 dB." by "with noise figures of 10 dB."

Abbreviations

- p. xxxiii: "CPC Cognitive Plot Channels" should be"CPC Cognitive Pilot Channels";

- p. xxxiii: "DAA"should be"DA";

- p. xli: PDC: "Pacific Digital Cellular" should be replaced by "Personal Digital Cellular"

- p.xiv "TE Temporal Reference"should be "TR ...";"TE Transmitted Equipment"should be"TR ...";

Symbols

- p. xlix "v singlar vector" should be"v singular vector";

- p. l "$B(\nu f)$"should be "$B(\nu, f)$"