Issues and errata in Vol. 1 of the ARRL Antenna Handbook (25^{th} ed.)

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Chapter 1

The first equation on page 1.12 uses very unconventional and confusing nomenclature. We have the ratio $P_0/P_{R,}$ which should be dimensionless except P_0 is in units of Watts and P_R is in units of W/m^2. One of these entities should be written with a different alpha-numeric character, perhaps I_R for intensity. Note the equation for G on the same page forms a ratio with two P terms that is dimensionless as we would expect.

Chapter 2

Figs 2.9-2.14 and 2.28-2.29 plot Reactance (ohms) vs Real (ohms). More consistent to have the x-axis labeled as Resistance, which is the real component of impedance.

Fig. 2.27 has an inset showing calculated radiation resistance out to 540 degrees or 1.5 λ. There is no discussion of this inset in the text. Since the inset is the same calculation as the primary plot (270 degrees or 3/4 λ) except over a longer range, why not use it instead? The x-axis maximum for the main plot is incorrectly stated as λ/2 in the figure caption.

On page 2.16, Figures 2.25 and 2.26 should be 2.28 and 2.29; similar error in the caption for Fig 2.29.

Table 2.3 is missing parentheses defining the units: Hp(λ), h_e(λ), Ae(λ), Rf(Ω). h_e is never defined. Is this h_{eff} or h_{elec}? It is unconventional to place the explanatory text: “Notice that the maximum possible…” *inside* a chart box. It should be in the main text. This is also the first mention of an infinitesimal dipole. Where is this defined or described? The concept of “loading” also appears for the first time, but it has never been defined.

The discussion in section 2.2.8 seems to be referring to a missing figure. I do not see how we get 22 Ω and 1.25 dBi from Fig. 2.27.

Chapter 3

Fig 3.5 and the accompanying text claims that the rotating H-field emanating from a vertical monopole will induce radial ground currents I_H. This is an incorrect interpretation of Faraday's Law of Induction, as explained here:

https://www.sportscliche.com/wb2fko/radials.pdf

The inset of Fig 3.10 lists Pr = 155 W, when the input power is stated to be 1500 W elsewhere. This looks like a typo. The use of Pr is an unconventional choice for labeling *input* power; why not Pi or Po? We see the numbers 0.005/13 in the inset of Fig 3.11 but they are not identified.

On page 3.6 it is stated: “The following graphs for field intensities assume perfect ground”. But in the immediately following paragraphs we read about ground losses and the use of non-perfect 0.005/13 soil for the analysis shown in Fig 3.11.

On page 3.7, there is italicized text that says: *Reducing R_g is the purpose of the ground system*. This is inconsistent with the discussion in Section 2.2, where the role of ground is to form an electrical image of the vertical monopole.

Figure 3.14 shows diagrams for two antennas labeled Antenna 1 and Antenna 2, apparently linked by a lightning bolt (radio wave). The text does not mention Antenna 2 and there doesn't appear to be any reason for its inclusion here, making the figure confusing.

The discussion involving Figs 3.15 and 3.16 is exceptionally difficult to understand. I eventually determined that these plots are obtained from the companion Appendix C for the 2015 QEX article by N6LF. The y-axis for amount of loss is incorrectly labeled as Ω (ohms), when it should be Watts. What I think Fig 3.15 is trying to convey: At different vertical antenna heights, the input power is adjusted to produce the same radiated power of 1500 Watts. The drive power must be increased as the height decreases. The curves appear to show a cumulative power integral in the radial direction, with contribution to the integral decreasing with increasing radial distance. There is nothing describing this integration in the figure caption or text. This strikes me as a very opaque approach for illustrating the inefficiency of short verticals. Certainly a single curve with relative efficiency plotted in units of dB vs antenna height in units of λ would make this point much more clearly.

Fig 3.16 shows that near-field loss (again incorrectly labeled with Ω) is dominated by the magnetic field. This is a very surprising result that is presented without explanation. Is this due to eddy currents in the soil?

Section 3.2.3 incorrectly states: “When the H-field passes over a conductor there will be a current induced in the conductor at right angles to the H-field vector”. This is not how magnetic induction works.

In Fig 3.19 the dashed vertical line to mark 0.375λ is incorrectly placed at 0.4λ.

First sentence of section 3.2.4: “Ground systems can **be** elevated…”

Page 3.18 talks about black and red bars in Fig 3.33, but the Handbook is printed in gray-scale.

Section 3.3.1 never mentions what is actually happening, namely wave **interference**. When the direct and reflected rays are exactly in phase we have maximum constructive interference; exactly out of phase gives complete destructive interference. Everything else is somewhere in between.

The statement: “...180 degree phase difference between vertically and horizontally polarized reflections...” is confusing. The amplitude and phase of the orthogonal polarizations upon reflection from a surface will depend on the angle of incidence and the complex conductivity. This is calculated using the Fresnel equations with a complex refractive index as shown in Figs 3.48 and 3.50. Note the complicated phase relationships in these plots. These equations also lead directly to the pseudo-Brewster angle for vertical polarization. For this reason, the assertion that exactly out-of-phase image currents describe reflections of orthogonal polarizations from a finite conductivity surface (repeated on page 3.29) is difficult to understand.

The discussion of Fig. 3.47 also fails to invoke the concept of interference. It suggests that antenna radiation patterns can be explained by small vs large path differences, but this requires a definition of what is meant by “small” and “large”. This is unnecessarily vague: what’s important is when path differences are an integer multiple of a half-wavelength. The near-horizontal geometry in Fig 3.47B can cause a null or peak in pattern of a 144 MHz antenna if the path difference is only 1 meter!

The physical description of the pseudo-Brewster condition in section 3.3.3 is incorrect. The text suggests that interference between the direct wave and reflected wave causes cancellation (destructive interference based on relative phase angle) of the radiated signal. The Brewster angle has nothing to do with interference; it is simply the angle at which a vertically polarized wave experiences very weak reflection and instead gets almost entirely transmitted into the earth at that specific angle (see Fig 3.48). Because there is no reflected ray, it cannot interfere constructively or destructively with the direct ray. It is only a concern if we are trying to enhance vertically polarized antenna gain using ground reflections in the first Fresnel zone.

There are algebraic formulations of the Fresnel equations for reflection amplitude and phase that separate the real and imaginary components of the complex permittivity. Equations (9) and (11) on pages 3.27-28 require that the reader perform mathematical operations using complex numbers. Also, there is no diagram to define the angle Ψ. Is it with respect to the surface? Surface normal? Antenna axis?

Chapter 4

On page 4.3 it is stated that there is more atmospheric bending as frequency increases from HF into the VHF region. I am not aware of any data that supports this; the refractive index of air is essentially independent of frequency at radio wavelengths.

On page 4.4, the plasma frequency of the ionosphere does not have to be much, much greater than the radio frequency to enable reflection. When the two frequencies are just equal, the refractive index vanishes and the plasma appears metallic to the wave at all incidence angles. Even with RF below the plasma frequency, partial Fresnel reflection will exist.

A signal cannot return to the earth by refraction in vertically stratified plasma layers. Ray tracing with Snell's Law demonstrates this mathematically. *Total internal reflection* from the ionosphere is what occurs. There may be a mixture of refraction and reflection, but only the latter gets the signal back to earth. The text tends to interchange reflection and refraction in places but they are distinctly different concepts, see:

https://www.sportscliche.com/wb2fko/csvhf2024_final.pdf

Section 4.1.4 describes how the size of particles is important for scattering and then gives examples of raindrops and "electron masses". While electron scattering is a real phenomenon, it has nothing to do with their size or mass, at least when talking about radio waves. The electron charge and its interaction with the E-M field are what's relevant. Pockets of atmospheric turbulence would be a better example of an RF scattering source.

Misunderstanding on page 4.9: When a signal is above the critical frequency at normal incidence, there can be partial Fresnel reflection. At sufficiently high frequencies, the plasma is transparent. Refraction back to earth, however, is not possible with ionization layers that follow the earth's curvature; again this can be demonstrated by ray tracing with Snell's Law.

In a uniform plasma, the critical frequency is the same thing as the plasma frequency. When RF is at or below the critical frequency, the signal is **reflected** at all angles of incidence including vertical. When the RF is above the critical frequency, then the incidence angle is important via Snell's Law and the Fresnel equations.

The paragraph on virtual height again assumes that refraction is returning the signal to earth and an equivalent reflection height can be defined. This is a misunderstanding of the physics of refraction (see linked paper above).

Point of semantics on page 4.12: JT65 and FT8 do not “reject noise” in the same way as filters or noise-blankers, for example. These modes use Forward Error Correction and averaging to retrieve signals that are very weak and competing with noise. The WSJTX modes don't suppress noise -- they deal with it.

Page 4.30 repeats the error about refraction. There is negligible variation of the air refractive index in the range of HF to microwave. The statement that “higher frequencies are more sensitive to refraction” has not been reported in any published measurements. Tropo-*scatter*, in contrast, becomes much stronger as the wavelength decreases.

The concept of an anomalous “waveguide” or duct in the troposphere to explain long-haul VHF+ DX appears to have grown out of amateur radio folklore. I haven't found much of anything in the peer-reviewed scientific literature suggesting such a physical picture. It is not supported by rigorous analysis. I believe the cause of tropo-ducting is unsettled science, but admittedly not an important component of the Antenna Handbook.