Extra Class License Manual – Supplemental Information and Errata

31 May 2018

The following text is intended to support or correct the 11th edition of the *Extra Class License Manual* and the 4th edition of the *Extra Class Q&A*. Recent change in this version of the document are in red.

Determine the version of the manual you are using by referring to the first page of the preface inside your copy. Look for the text box with the copyright information where you'll also find the edition and printing information. (If the edition number is not followed by printing information, the book is the first printing.) If the material does not refer to a specific printing, it applies to all versions of the manual.

The question pool for the current Extra Class license took effect on July 1, 2016.

Question Pool Changes

None.

Supplemental Information

Extra Class License Manual

Significant Digits in Answers: Students may be confused when making calculations because the answer in the question pool or example does not reflect the exact number produced by a calculator. For example, when calculating reactance in Example 4.4 on page 4-22, using the formula for X_L a calculator will display a value of 396.2052. Following the rules of significant digits, the answer should be rounded to 400. A tutorial on significant digits is available online at **chemcollective.org/activities/tutorials/stoich/significant_figures** as well as through the online Khan Academy (**www.khanacademy.org**). Although the question pool is not completely consistent regarding significant digits in calculations, the student should expect answers to be rounded or refer to "best representations" to accommodate different methods of calculation. The associated question to this calculation (E5C15) asks only which of the graphed points "best represents" the resulting impedance, for example. High precision is not required in any exam question.

Chapter 4

Page 4-29

Figure 4.24 shows the intersection of two lines representing reactance vs frequency: the curved line, decreasing to the right, shows capacitive reactance $X_C = 1/2\pi fC$, and the straight line rising to the right shows inductive reactance $X_L = 2\pi fL$. At the frequency where the lines cross, $X_C = X_L$ and the circuit is resonant. The scales of both axes are linear, resulting in the curved and straight lines. In most engineering manuals and texts, however, reactances are plotted on a log-log chart where both types of reactance are plotted as straight lines. This makes it a lot easier to see where the resonant frequency is for a wide range of capacitance, inductance, and frequencies. You can see this kind of chart in the Electrical Fundamentals chapter of the *ARRL Handbook* or online at **www.rfcafe.com/references/electrical/frequency-reactance-nomograph.htm**.

Pages 4-37 through 4-39

Note that the question pool uses the <u>incorrect</u> units for A_L in calculating the answers for E6D01 and E6D11. The correct units are microhenries per 100 turns **squared**. The answers are numerically correct. This error stems from an error in a widely used data sheet for toroid cores from a popular vendor.

Chapter 5

Page 5-21

In Figure 5.38 - the first line of the state table (B) for S = 0 and R = 0 is saying "If S and Rare both zero, the states of the Q and not-Q outputs are unchanged."

In the bottom line of the truth table, the output states are uncertain for S = 1 and R = 1 because both Q and not-Q attempt to go to the *same* state, which is not allowed for complementary outputs. Either 0 or 1 would possible - see https://en.wikipedia.org/wiki/Flip-flop_(electronics). Whether it is 0 or 1 depends on exact timing of signal changes and similar concerns. This is one reason why the S-R flip-flop isn't often used in favor of a clocked D-type or J-K flip-flop.

Chapter 6

The symbol // (two parallel slashes) is used to mean "in parallel with" instead of showing the full equation for the paralleled components. Using // is often clearer than the full equation when attempting to explain a design or relationship.

Page 6-3

The discussion of biasing techniques that supports question E7B10 through E7B13 and E7B15 doesn't use the term "fixed bias" in the most common way. Most sources now refer to the four-

resistor circuit of Figure 6.1 as "voltage divider bias" which more accurately describes the function of the circuit. The answer to question E7B10 – B. Fixed bias – is not strictly wrong but it is not reflective of the widest use of the term. This will be re-evaluated when the Extra Class question pool is next reviewed. In the meantime, use the pool's current answer and be aware that there are several terms used to describe the various biasing circuits for transistor amplifiers.

Page 6-14

In Figure 6-13, the symbol β (beta) is used to represent the feedback ratio through the feedback network. While this is standard terminology (en.wikipedia.org/wiki/Barkhausen_stability_criterion), beta is also used to represent the ratio of collector to base current in a bipolar transistor. The context of the discussion should be used to alert the reader which meaning of the symbol is used. There are many symbols with multiple uses in electronics – caution is advised, along with a good glossary.

Page 6-40

The phrase *"As a pulse becomes narrower and narrower, its frequency spectrum spreads out more and more"* can be hard to understand. Without getting into the full mathematics of the spectrum of pulses, we can simplify the reasoning a bit as follows: As the pulse becomes narrower in time, higher and higher frequency components are required to make the sharp edges with the short duration between them. At the extreme, the spectrum of a zero-width impulse has components at _all_ frequencies. This is why impulse noise, such as from arcs and spark discharges, has such a wide spectrum and creates interference across a wide frequency range. Similarly for key clicks - the sharper the keying, the worse the clicks become.

Page 6-42

Question E7C11 refers to "back-to-back" L networks forming a Pi network. This is described by Figure 6-42 – imagine L1 in that figure being divided into two series inductors, L1A and L1B. The combination of C1 and L1A forms an L network and the combination of L1B and C2 forms another L network. When connected this way the inductors of the two L networks are in series and the capacitors are connected in shunt at the Pi network's input and output.

Page 6-44

The function of the linear regulator circuit on the exam (Figure E7-3) is easier to understand if both Figure 6.46 and Figure E7-3 are available while reading the explanation of the circuit's function on page 6-45. The schematic in Figure 6.46 is more typical of an actual linear regulator than the exam figure which is somewhat oversimplified.

Chapter 7

Page 7-2

Regarding the sentence, *"The rotation of the wheel and the repeated cycles of the sine wave can also be described by a vector that is rotating (spinning around like the hands of a clock) at the frequency of the sine wave."* It is important to note that the vectors are spinning counter-clockwise – from 0 to 90 to 180 to 270 and back to 0 degrees.

Chapter 9

A resonant antenna has a feed point impedance that is all resistance. i.e. $Z = R + j0$. Yet the current and voltage appear to be 90 degrees out of phase at resonance – why?

The drawing shows the current and voltage distributions. The distributions along the wire are just the magnitude of the waveforms (like the envelope of a modulated signal) and doesn't say anything about the phase of the actual waveform. It is the distributions that are 90 degrees out of phase, not the waveforms. At the center, the voltage waveform reaches a minimum while the current waveform is at a maximum - yet both waveforms are in-phase (at resonance), resulting in a purely resistive impedance.

Page 9-31

In the first paragraph's explanation of the function of the hairpin inductor, it is correct that the hairpin is a shunt inductor. [E9E06] This shunt inductor then combines with the capacitive reactance of the antenna's driven element to form an L network, matching the antenna's feed point impedance to 50 ohms.

Extra Class Q&A

None

Errata

Extra Class License Manual

Page references for the following questions are off by one page:

Question	Chapter	Page Ref.	Correct Page
E1B06	3	8	9
E1E09	3	17	18
E1E10	3	17	18
E2B08	8	22	23
E2D11	2	11	12
E3A01	10	15	14
E3A02	10	14	15
E3A03	10	15	14
E4C04	7	17	18
E4C13	7	20	19
E6A09	5	10	11
E6A10	5	10	11
E6A12	5	10	11
E6A14	5	10	11
E6C01	6	9	10
E6F05	5	27	29
E6F06	5	27	28
E6F07	5	27	29
E6F08	5	26	28
E7C11	6	42	43
E7F15	6	40	41
E7H04	6	(none)	15
E8B11	8	5	6
E8D04	8	10	11
E9H11	9	24	25

Page 2-7

Remove [E2C04] at the end of the first paragraph.

Page 2-9

Remove E2C04 from the blue box at the bottom of the page so that the questions references are E2C01 through E2C03, E2C07, and E2C13.

Page 3-12/3-13

Change the sentence spanning the two pages to read "…located more than 50 km above the Earth's surface."

Page 3-17

In the first paragraph of "During the Exam," change "station" to "session."

Page 3-21

The blue box listing questions for Spread Spectrum Operation should only list questions E1F01, E1F09, and E1F10.

Page 4-2

In the first paragraph of "Complex Coordinates" the sentence on lines 5 and 6 should read, "Any number based on $\sqrt{-1}$ is called an *imaginary number* to distinguish it from the real numbers."

Page 4-21

In the section "Calculating Impedances and Phase Angles" the sentence beginning the third paragraph should read, "Note that when combining parallel elements, it is often easiest to convert them to conductances or **susceptances** which can be added directly together."

Page 4-32

In the paragraph following equation 4.16A, change line 4 to read "will always go down…"

Page 5-25

At the end of the first paragraph, change the reference to Figure 5.43 to Figure 5.42.

Page 6-4

The numerator of equation 6.1 should be $-[(R3+R4)//R_L]$. The notation ""X // Y means 'the parallel combination of X and Y'" as a way avoiding having to write the full equation.

Page 6-7

In the final paragraph and continuing on page 6-8, the reference to a closed-loop circuit should be to an open-loop circuit.

Page 6-10

Under the title, "Classes of Operation" in the second paragraph's line 8, the word, "operator" should be changed to "operate."

In the page's first full paragraph, the text in parentheses and the following sentence refer to a figure that was removed in the 11th edition. That text can be ignored.

Page 6-20

Change the mid-page figure reference from 6.23 to 6.18.

Page 6-22

In the first paragraph – the reference to Figure 6.25 should be to Figure 6.20

Page 6-23

Page 6-23, third paragraph, last sentence, delete the first "block" in "The block diagram shown in figure 6.22 shows the block diagram. . . ."

Page 6-40

In the caption for Figure 6.38, "bn" should be "b_n".

Page 6-41

In the second paragraph, the first sentence should read "Unlike a symmetrical FIR filter, frequency components of the input signal can be delayed by different amounts."

Page 7-10

In Example 7.3, change the reference to Equation 7.8 from 7.7.

In the first paragraph's second line, "frequency" should be "time".

Page 7-19

In the third paragraph of the Analog Receiver IF Filters section, change the third sentence to begin, "Their purpose is to increase receiver dynamic range by rejecting as many…" This creates a stronger explanation for the answer to referenced question E4C13.

Page 7-23

The second equation at the top of the page should be $f_2 = (14.035 + 14.020) / 2 = 14.0275$ MHz.

Page 8-4

The answer to Example 8.4 should be 3, not 312.

Page 8-7

Under title "Data Rate vs Symbol Rate", second paragraph, fifth line, strike the word "the" between the words "send" and "both".

Page 8-16

Add question E2C04 to the question reference [E2C09] and add question E2C04 to the blue box at the bottom of the page.

Page 9-11

Under title, "Folded Dipole", second paragraph, second sentence, "Figure 9.11" should be replaced with "Figure 9.7".

Page 9-15

First paragraph, line 8, change "Figure 9.9" to "Figure 9.13".

Page 9-40

Figures 9.33 and 9.34 show behavior of transmission lines up to 1 λ long instead of 2 λ

Page 9-41

In Figure 9.35, the labels for impedances, left to right, should be Z_0, Z_1, and Z_{LOAD} in order to agree with text preceding equation 9.14.
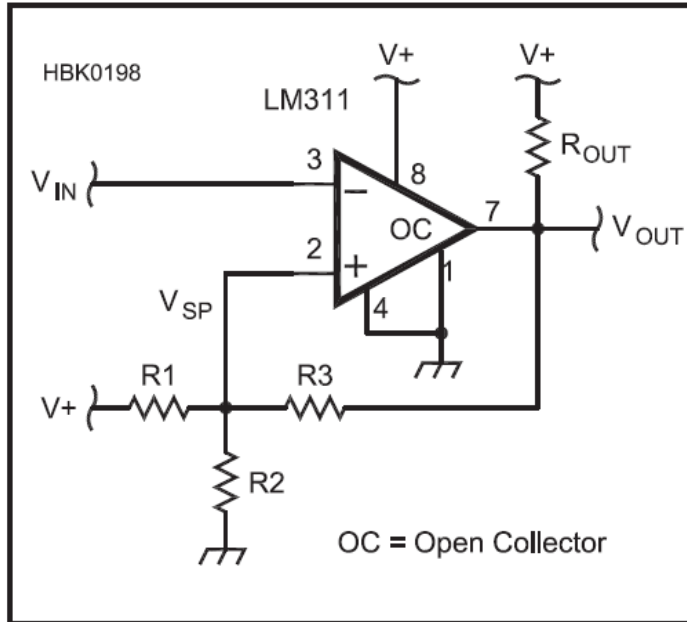
Page 9-42

Line 14, the word "cause" should be changed to "caused".

Question Pool: E2C04 – the referenced manual page should be 8-16.

Extra Class Q&A

E2A05 – In Table E2-1, swap the header labels "Downlink" and "Uplink" – the left-hand column (Satellite Receive) is the Uplink frequency.

E6C01 – Figure E6C01 should be graphic HBK0198 as shown below:

E7A07/08/09 — Table E7-1 mistakenly shows the outputs of an XNOR gate in the right-most column instead of an XOR. The label at the top of the column should be "XNOR".

E7G04 – the explanation should refer to an open-loop circuit, not closed-loop. This is the revised explanation: Op amp input offset voltage is the dc voltage between the input terminals required to bring the output to zero in an open-loop condition. It is measured by adding a differential voltage to the input terminals such that the output voltage is returned to zero. Offset results from imbalance between the IC's input transistors and their biasing circuits.

E8A09 - The correct answer is D, not C.

E8B04 – The answer to the calculation is 3.

E9E06 – Answer C should read "A shunt inductor"