Designing Control Loops for Linear and Switching Power Supplies: A Tutorial Guide – 2nd print

Christophe Basso – April 2014
Last update September 2015

Corrections of typos, mistakes and errors found by readers or by the author himself.

Page 12: figure 1.13, a "-" sign is missing at the end of the vertical arrow, below the first summation circle.
Contributed by Ken Shirriff, April 2014

Page 13: …value. After a certain time designated as…
Contributed by Ken Shirriff, April 2014

Page 13: …be approximated by a linear system…
Contributed by Ken Shirriff, April 2014

Page 16: a possible test fixture... not text fixture
Contributed by Ken Shirriff, April 2014

Page 16: figure 1.17, …(amplitude-phase couples) are recorded at each frequency step.
Contributed by Ken Shirriff, April 2014

Page 17: The decibel, one tenth of a bel not a bell.
Contributed by Ken Shirriff, April 2014

Page 17: …compress the *x* and *y* axes.
Contributed by Ken Shirriff, April 2014

Page 17: End of the page: … the ratio increase between the second point and the starting point.
Contributed by Ahmed Yousef, September 2015

Page 18: …the corner frequency is the frequency at which the transfer function magnitude...
Contributed by Ken Shirriff, April 2014

Page 18: above equation (1.18), last bullet:…in other words,

$$S = \frac{y_2 - y_1}{x_2 - x_1} = \frac{y_2 - y_1}{\log_{10} f_2 - \log_{10} f_1} \qquad (1.18)$$

(1.19) needs an update as well:

$$S = \frac{-20}{\log_{10}\left(\frac{10 f_1}{f_1}\right)} = -20\,\text{dB/dec} \qquad (1.19)$$

Page 19: …of its terminal's voltage (actually…
Contributed by Ken Shirriff, April 2014

Page 19: Second paragraph: A first-order system exhibits an up or down slope of 1 or -1, respectively, implying…
Contributed by Ahmed Yousef, September 2015

Page 20: …into a two-dimensional plane, the complex…
Contributed by Ken Shirriff, April 2014

Page 20: …and $Y(s)$ are functions of a complex…
Contributed by Ken Shirriff, April 2014

Page 20: …that positive time only *remove comma* is considered (the function is said…)
Contributed by Ken Shirriff, April 2014

Page 22: Figure 1.20: …by s after going through…
Contributed by Ken Shirriff, April 2014

Page 25: Figure 1.22: capacitor C_1 should be 0.1 µF in the Mathcad sheet.
Contributed by Ken Shirriff, April 2014

Page 26: Figure 1.24: when combining asymptotic responses,…
Contributed by Ken Shirriff, April 2014

Page 52: in Figure 2.16, all subscripts should be s_p and not s_z.
Contributed by Martin Svensson, April 2014

Page 48: In equation (2.90), the real parts have to be updated when the capacitor ESR goes to zero:

$$s_1 = -4.8k + j31.4k$$

$$s_2 = -4.8k - j31.4k$$

Contributed by Ahmed Yousef, September 2015

Page 48: As a result, the resonant frequency definition must also change but the result is unaffected:

$$\omega_0 = |s_1| = |s_2| = \sqrt{(4.8k)^2 + (31.4k)^2} = 31.73 \text{ krd/s or } 5.05 \text{ kHz}$$

Contributed by Ahmed Yousef, September 2015

Page 51: End of bullet 4: It is important to note that if the real part is 0, we have imaginary pole pairs of the form $p_i = \pm j\omega$.
Contributed by Ahmed Yousef, September 2015

Page 57: above (2.105) of course, “surface” has a different meaning in English: …circulating in the load is the area of A_0, averaged…

Page 58: below Figure 2.22: In theory, the new *area*, A_1, should be…

Page 60: a typo in (2.113), the square in the denominators is missing.

$$\Delta I_L = \frac{V_{in}}{R_{load}}\left[\frac{1}{(1-D_1)^2} - \frac{1}{(1-D_0)^2}\right] = \frac{10}{240}\left[\frac{1}{(1-0.59)^2} - \frac{1}{(1-0.583)^2}\right] = 8.25 \text{ mA}$$

$$dt = \frac{8.25m}{160u} = 51.6\ \mu s$$

In the text below, replace 10.6 µs by 51.6 µs.
Contributed by Orestis Polychronakis, February 2015

Page 215: equation (4.156) is suspicious. I actually took it from the paper referenced in [8] and included it without thinking it could be wrong. If you replace the definitions of the terms in a as defined page 214, you find a equals 0. I was alerted by a student, Siyu He, about this strange result and I decided to re-derive the equation myself. Develop (4.153) and rearrange the polynomial form, factoring s and s^2. You should find

$$G(s) = \frac{R_0 - r_C}{H_0 r_C} \frac{1 + s\left(\frac{QR_0\omega_0\omega_{z_1} - r_C\omega_{z_1}\omega_{z_2} + QR_0\omega_0\omega_{z_2}}{Q\omega_0\omega_{z_1}\omega_{z_2}(R_0 - r_C)}\right) + s^2 \frac{R_0\omega_0^2 - r_C\omega_{z_1}\omega_{z_2}}{\omega_0^2\omega_{z_1}\omega_{z_2}(R_0 - r_C)}}{1 + s\left(\frac{H_0Qr_C\omega_0^2\omega_{z_2}}{H_0Qr_C\omega_0^2\omega_{z_1}\omega_{z_2}}\right)}$$

after simplification we have

$$G(s) = \frac{R_0 - r_C}{H_0 r_C} \frac{1 + s\left(\frac{QR_0\omega_0\omega_{z_1} - r_C\omega_{z_1}\omega_{z_2} + QR_0\omega_0\omega_{z_2}}{Q\omega_0\omega_{z_1}\omega_{z_2}(R_0 - r_C)}\right) + s^2 \frac{R_0\omega_0^2 - r_C\omega_{z_1}\omega_{z_2}}{\omega_0^2\omega_{z_1}\omega_{z_2}(R_0 - r_C)}}{1 + \frac{s}{\omega_{z_1}}} = K_0 \frac{1 + a_1 s + a_2 s^2}{1 + \frac{s}{\omega_{z_1}}}$$

Considering a dominant low-frequency pole given by $1/a_1$, then the numerator simplifies to

$$G(s) \approx K_0 \frac{1 + s\left(\frac{R_0(\omega_{z_1} + \omega_{z_2})}{\omega_{z_1}\omega_{z_2}(R_0 - r_C)}\right)}{1 + \frac{s}{\omega_{z_1}}} = K_0 \frac{1 + \frac{s}{\omega_{z_G}}}{1 + \frac{s}{\omega_{p_G}}}$$

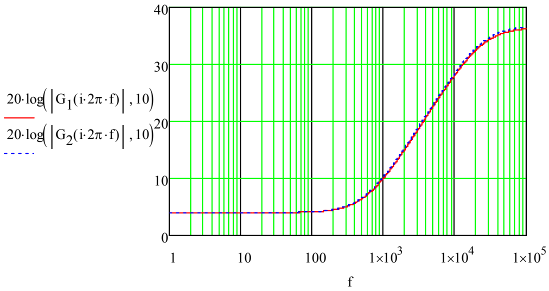
with

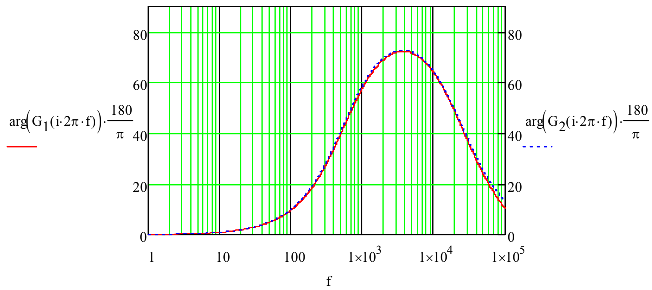
$$K_0 = \frac{R_0 - r_C}{H_0 r_C}$$

$$\omega_{z_G} = \frac{\omega_{z_1}\omega_{z_2}}{\omega_{z_1} + \omega_{z_2}} \frac{R_0 - r_C}{R_0}$$

$$\omega_{pG} = \omega_{z_1}$$

The response comparing (4.153) in $G_1(s)$ and the above equation in $G_2(s)$ is shown below





Motivated by Siyu He, April 2015

Page 330: equation (5.301), this is $V_{err}(s)/V_{out}(s) = \ldots$ and not $V_{op}(s)/V_{out}(s)$

Contributed by Raymond Carr, July 2014

Page 532: equation (9.78), a square is missing in the denominator

$$H(f)| = 20\text{Log}_{10}\left[H_0 \frac{\sqrt{1+\left(\frac{f}{f_{z_1}}\right)^2}\sqrt{1+\left(\frac{f}{f_{z_2}}\right)^2}}{\sqrt{\left(1-\left(\frac{f}{f_0}\right)^2\right)^2+\left(\frac{f}{f_0 Q}\right)^2}}\right]$$

Contributed by Edwin Marte, April 2015

Page 534: equation (9.85) went wrong and should be corrected:

$$|G(f)| \approx 20\cdot\text{Log}_{10}\left[\frac{R_2}{R_1}\frac{\sqrt{1+\left(\frac{f_{z_1}}{f}\right)^2}\sqrt{1+\left(\frac{f}{f_{z_2}}\right)^2}}{\sqrt{1+\left(\frac{f}{f_{p_1}}\right)^2}\sqrt{1+\left(\frac{f}{f_{p_2}}\right)^2}}\right]$$

Contributed by Raymond Carr, October 2014