Chapter 8: Converter Transfer Functions

Converter Transfer Functions

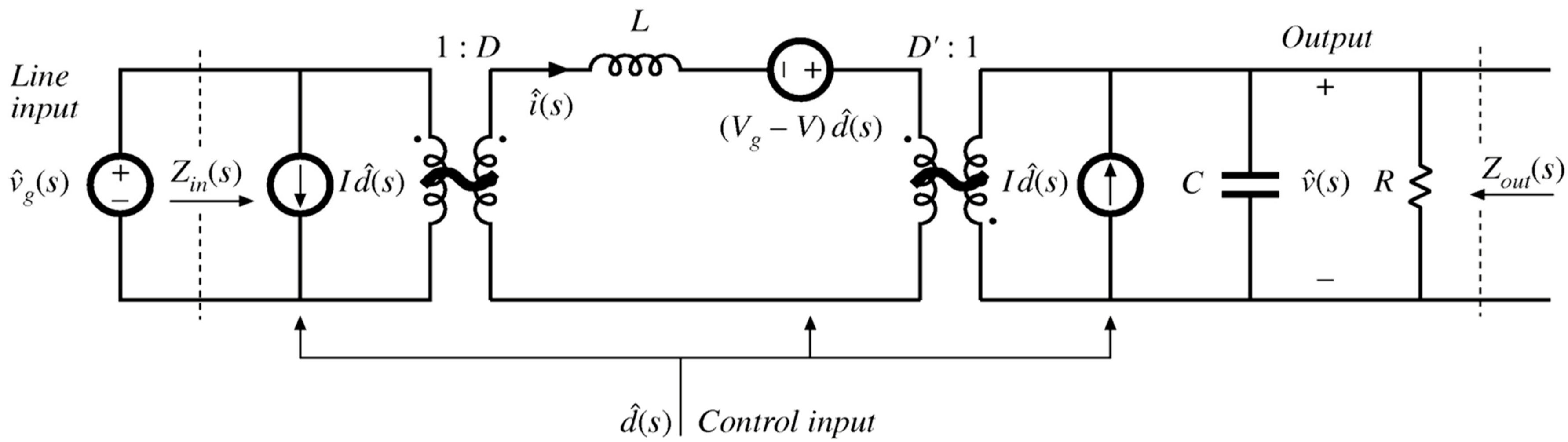
8.3. Graphical construction of converter transfer functions

- 8.3.1. Series impedances: addition of asymptotes
- 8.3.2. Parallel impedances: inverse addition of asymptotes
- 8.3.3. Another example
- 8.3.4. Voltage divider transfer functions: division of asymptotes

8.4. Measurement of ac transfer functions and impedances

8.5. Summary of key points

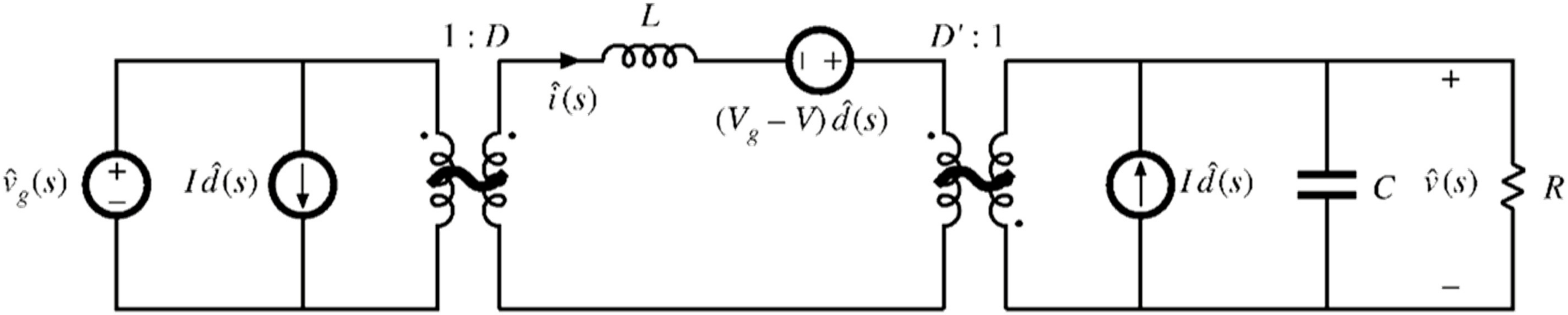
Buck Boost Model



$$G_{vg}(s) = \left.\frac{\hat{v}(s)}{\hat{v}_g(s)}\right|_{\hat{d}(s)=0}$$

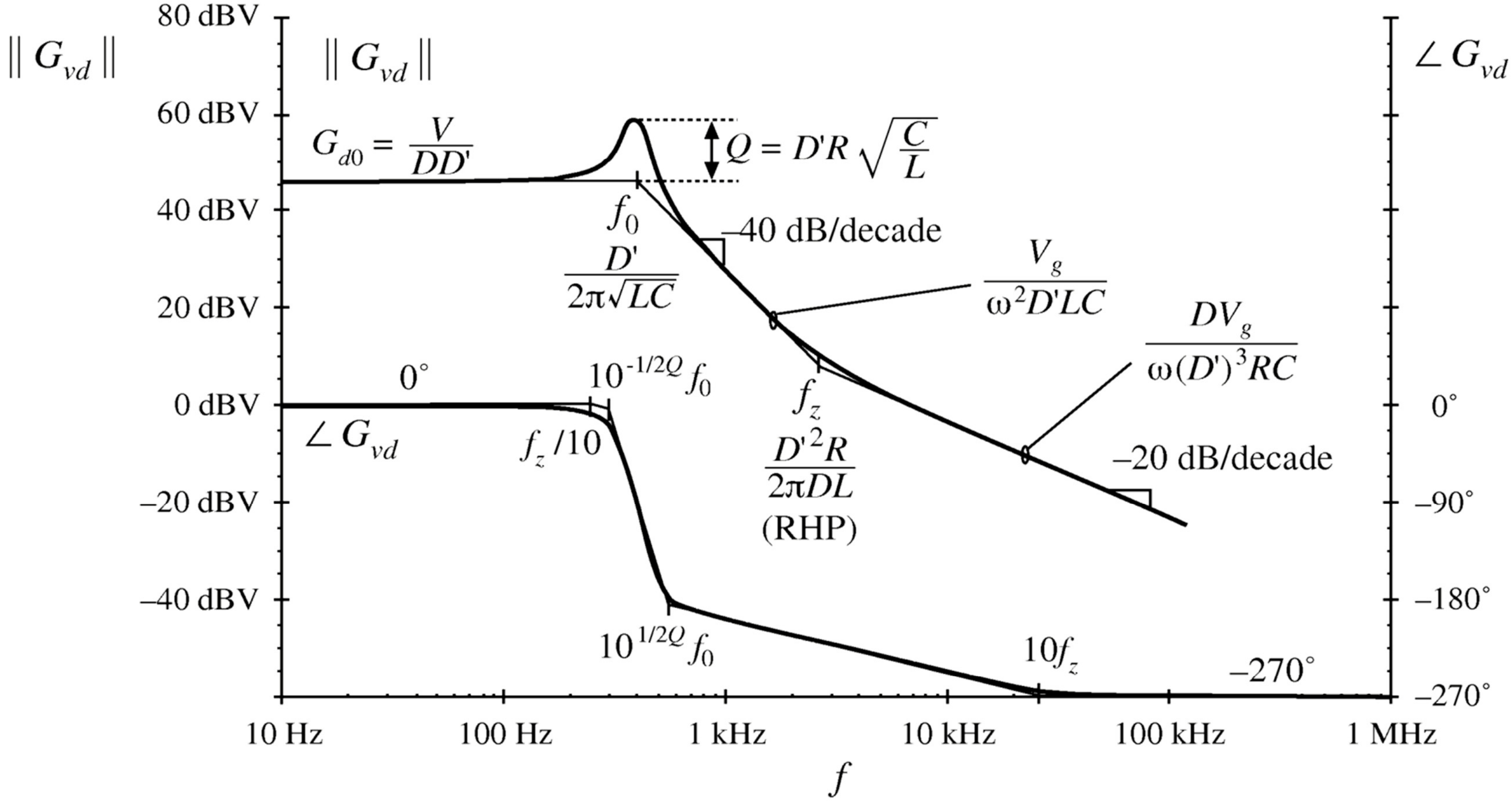
$$G_{vd}(s) = \left.\frac{\hat{v}(s)}{\hat{d}(s)}\right|_{\hat{v}_g(s)=0}$$

Buck-Boost Control-to-Output TF



Buck-Boost Control-to-Output TF

Control-to-output Transfer Function



Design-Oriented Analysis

How to approach a real (and hence, complicated) system

Problems:

- Complicated derivations
- Long equations
- Algebra mistakes

Design objectives:

- Obtain physical insight which leads engineer to synthesis of a good design
- Obtain simple equations that can be inverted, so that element values can be chosen to obtain desired behavior. Equations that cannot be inverted are useless for design!

Design-oriented analysis is a structured approach to analysis, which attempts to avoid the above problems

Chapter 8: Design-Oriented Analysis

- Writing transfer functions in normalized form, to directly expose salient features
- Obtaining simple analytical expressions for asymptotes, corner frequencies, and other salient features, allows element values to be selected such that a given desired behavior is obtained
- Use of inverted poles and zeroes, to refer transfer function gains to the most important asymptote
- Analytical approximation of roots of high-order polynomials
- Graphical construction of Bode plots of transfer functions and polynomials, to

    avoid algebra mistakes

    approximate transfer functions

    obtain insight into origins of salient features

8.1 Review of Bode Plots

Decibels

$$\| G \|_{\text{dB}} = 20 \log_{10}\left(\| G \| \right)$$

Decibels of quantities having units (impedance example): normalize before taking log

$$\| Z \|_{\text{dB}} = 20 \log_{10}\left(\frac{\| Z \|}{R_{base}} \right)$$

Table 8.1. Expressing magnitudes in decibels

Actual magnitude	*Magnitude in dB*
1/2	– 6dB
1	0 dB
2	6 dB
5 = 10/2	20 dB – 6 dB = 14 dB
10	20dB
$1000 = 10^3$	$3 \cdot 20$dB = 60 dB

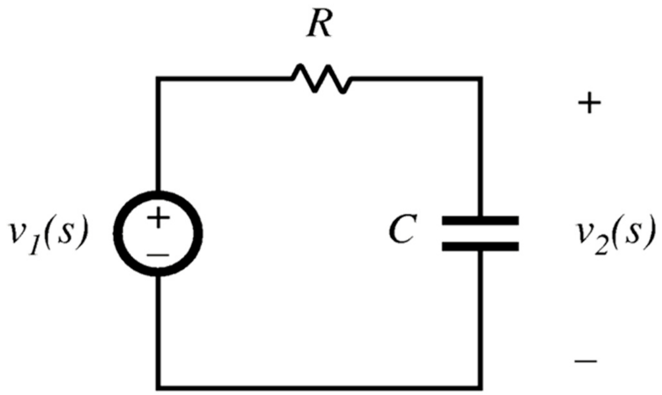
5Ω is equivalent to 14dB with respect to a base impedance of R_{base} = 1Ω, also known as 14dBΩ.

60dBμA is a current 60dB greater than a base current of 1μA, or 1mA.

Logarithm Review

Plotting on Logarithmic Axes

Single Pole Response

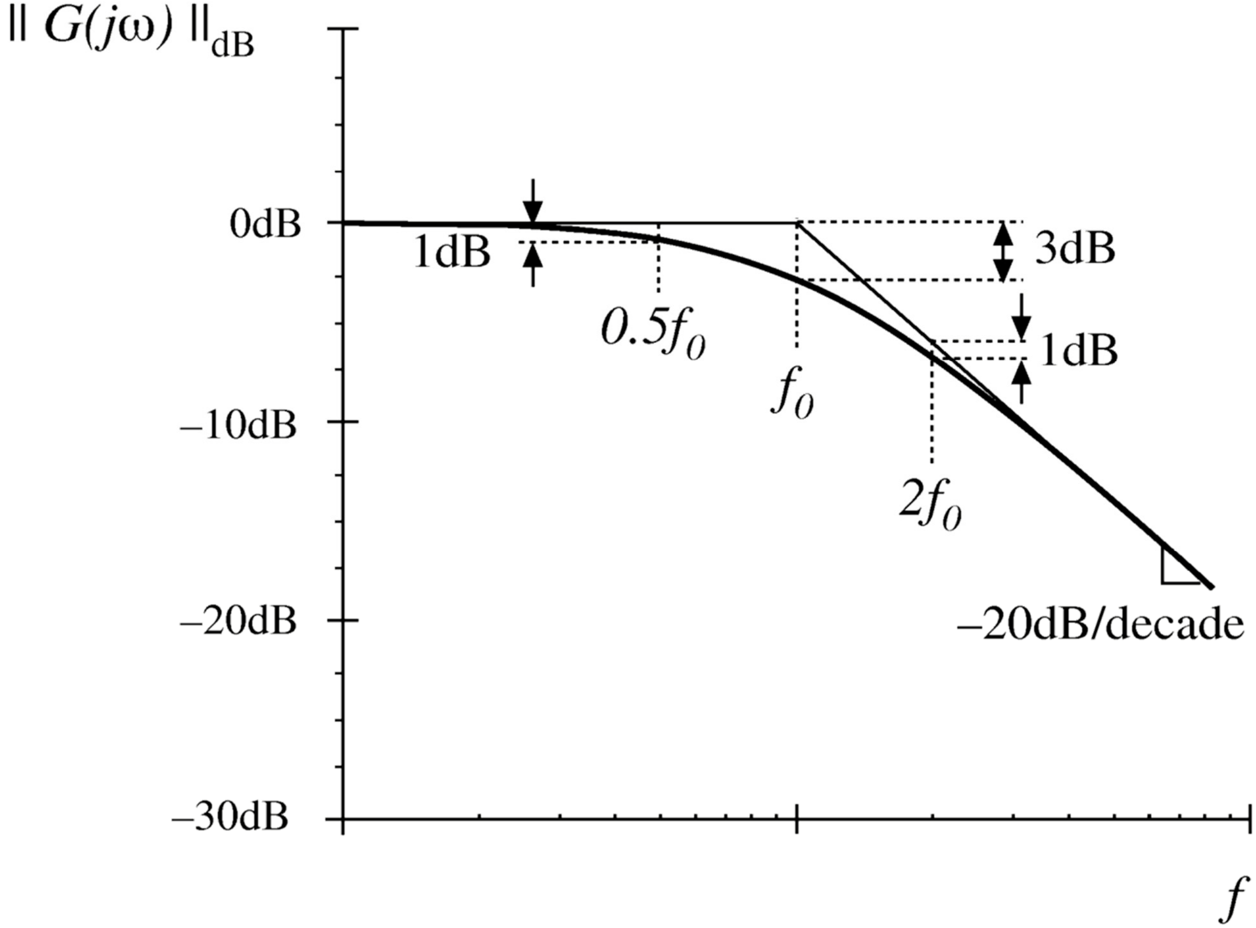


Magnitude of Single Pole Response

Plotting a Single Pole Response

Exact response near $f = f_0$

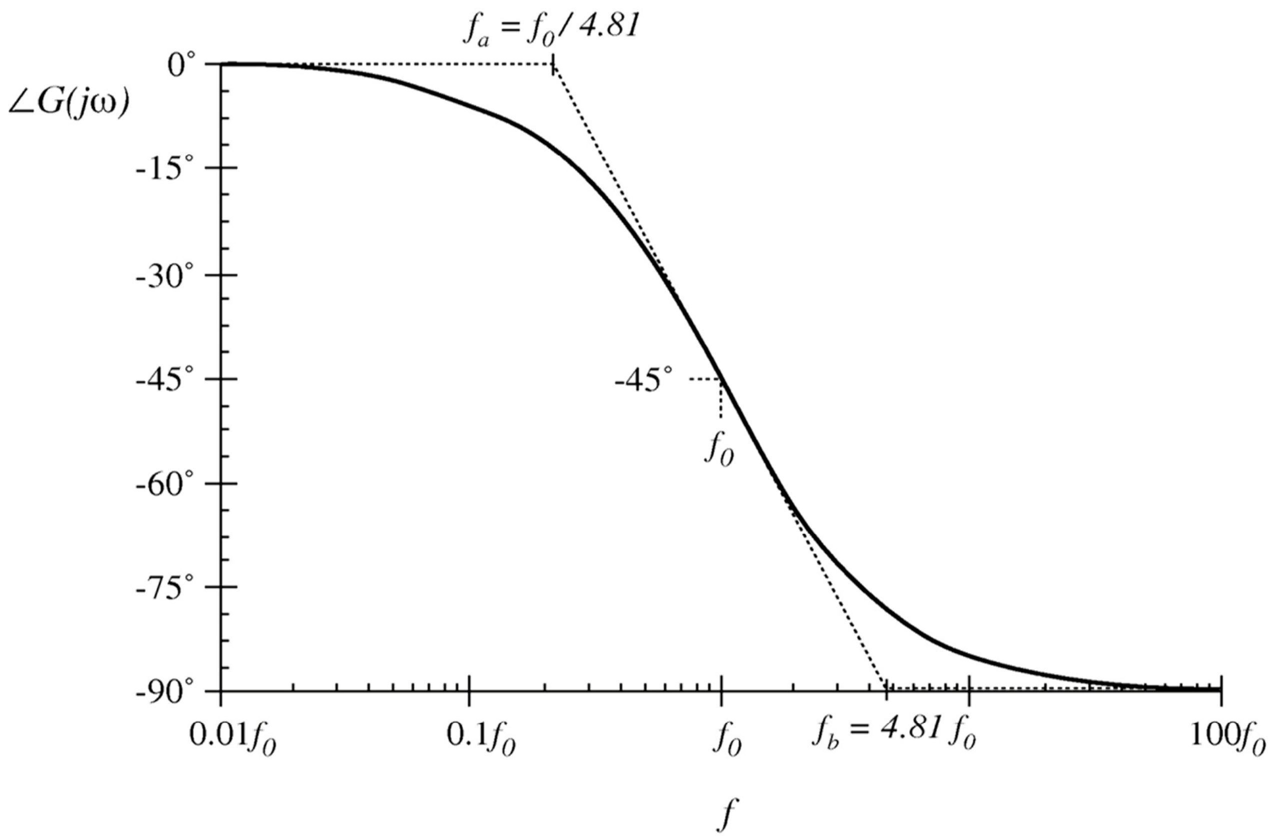
Summary: Single Pole Magnitude



Phase of Single Pole

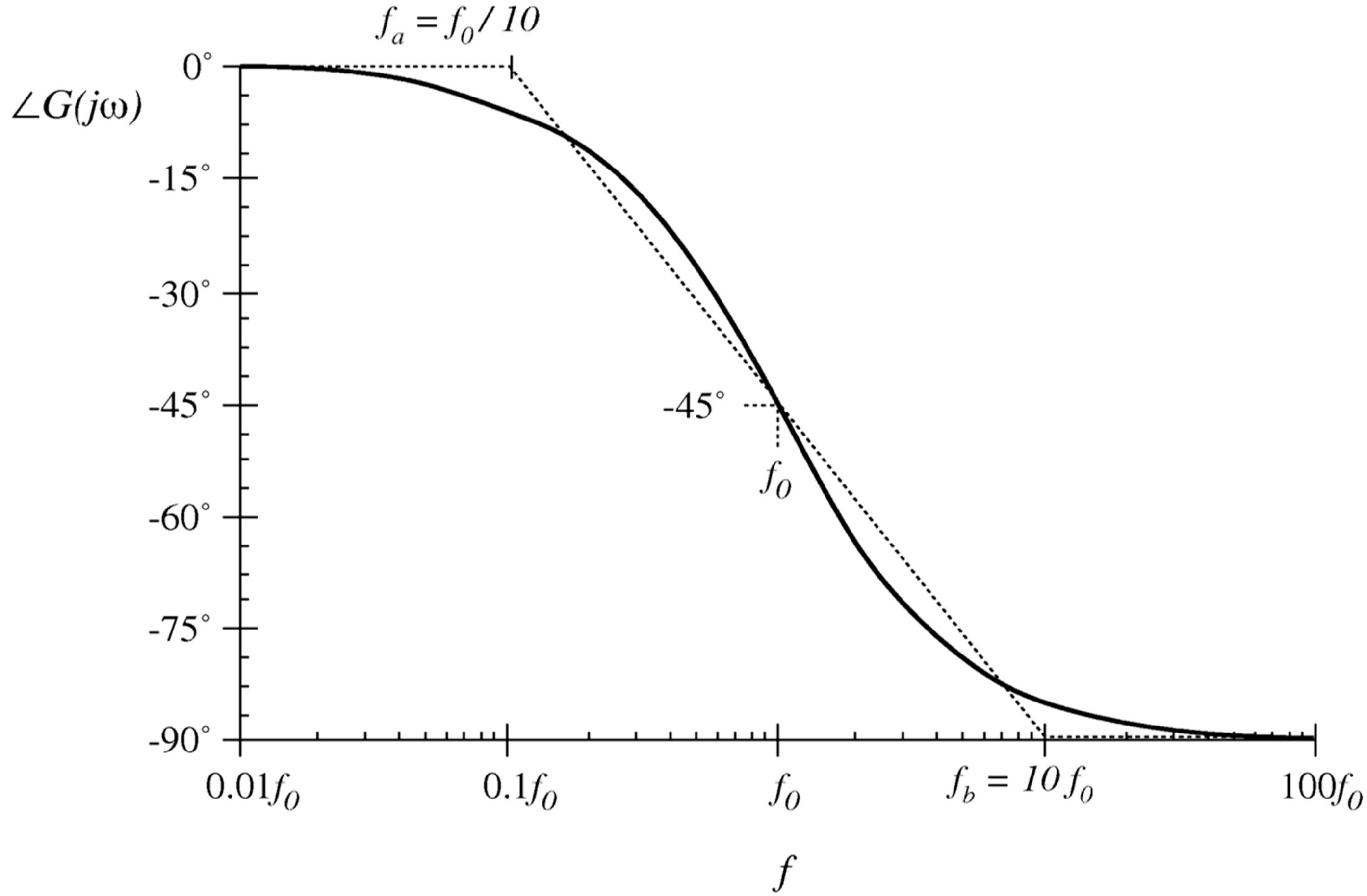
Phase Asymptotes

$$f_a = f_0\, e^{-\pi/2} \approx f_0 / 4.81$$
$$f_b = f_0\, e^{\pi/2} \approx 4.81\, f_0$$

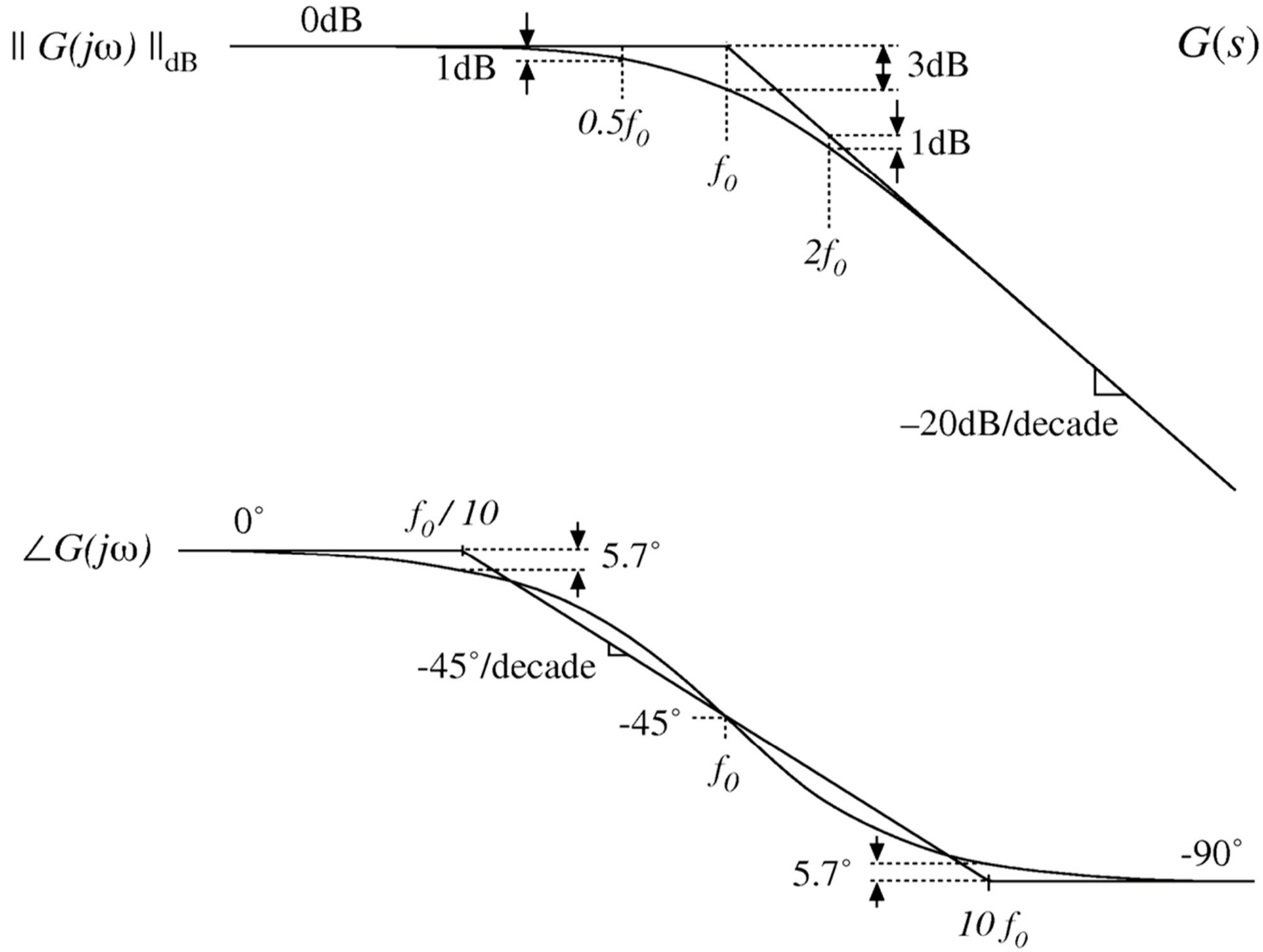


Phase Asymptotes: A Simpler Choice

$f_a = f_0 / 10$
$f_b = 10\, f_0$

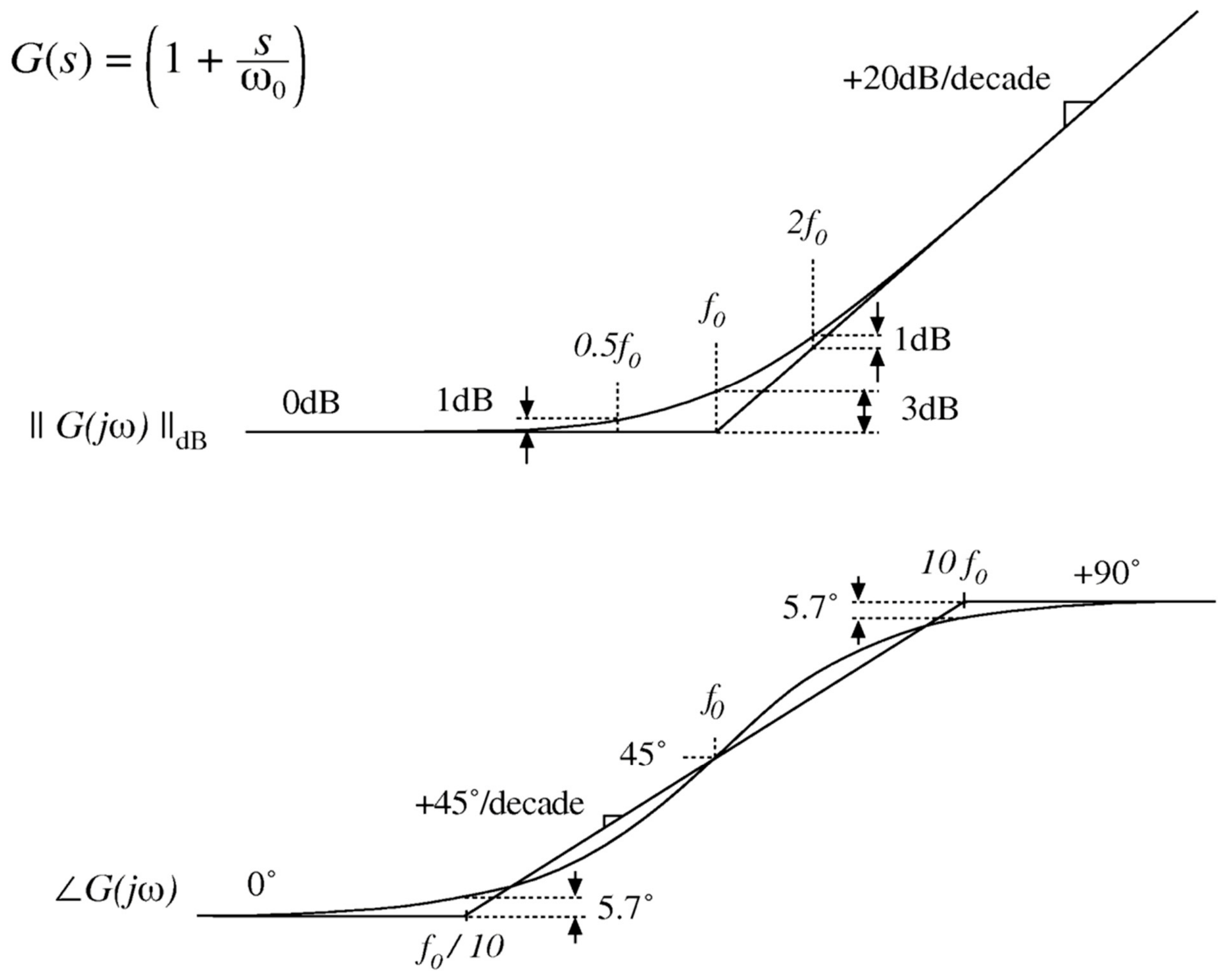


Summary: Single Real Pole

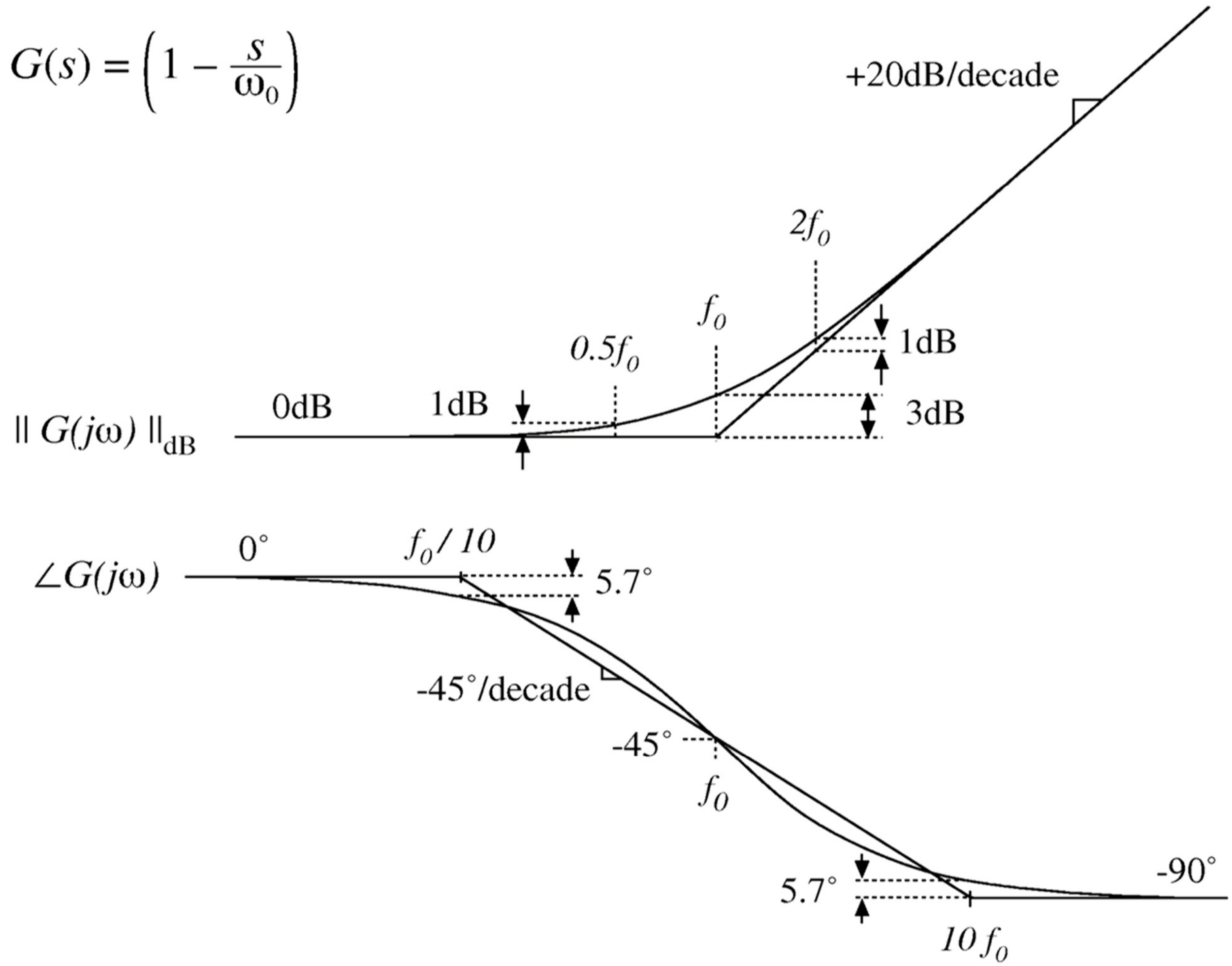


$$G(s) = \frac{1}{\left(1 + \frac{s}{\omega_0}\right)}$$

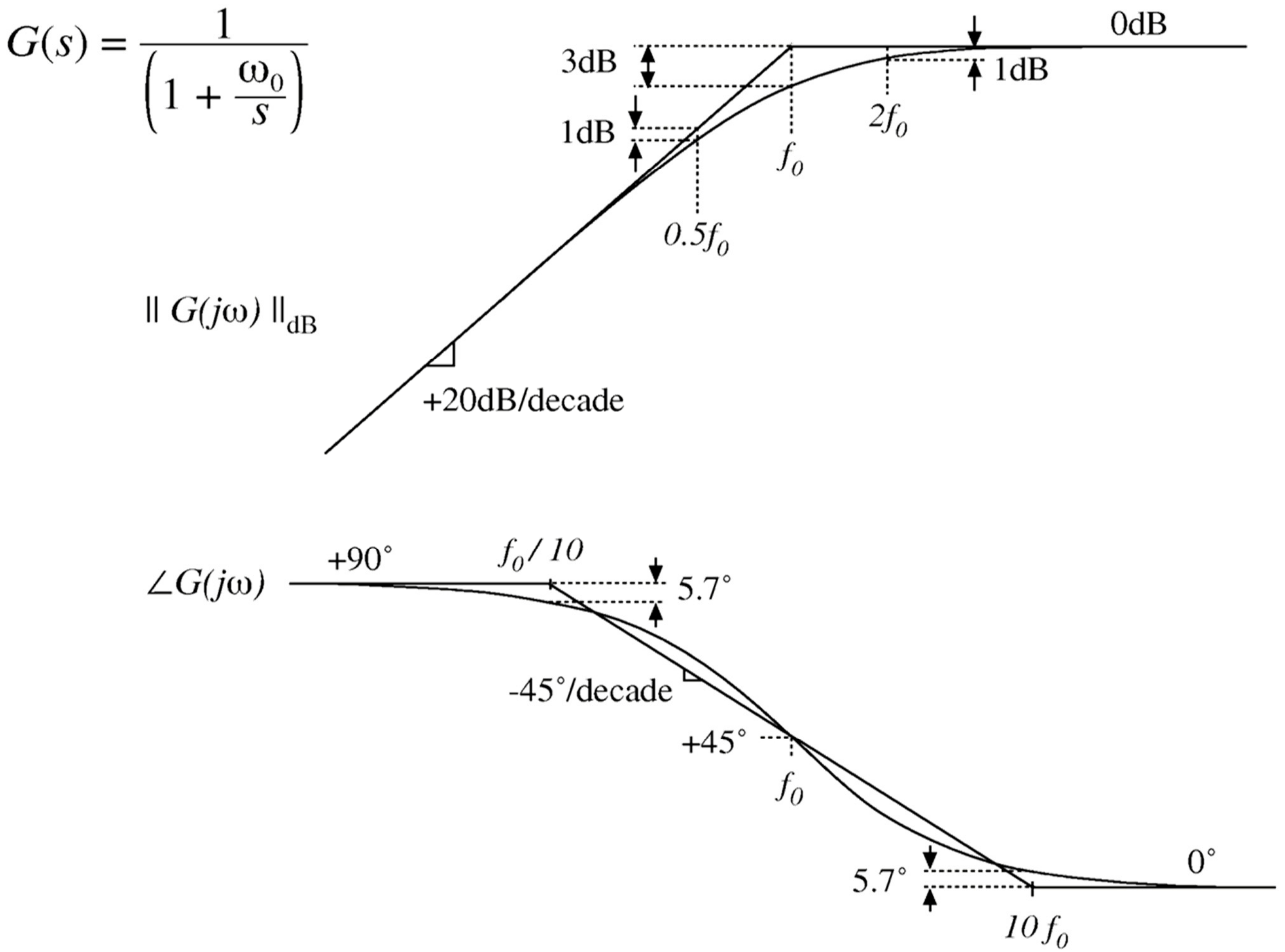
Bode Plot: Real Zero



RHP Zero


$G(s) = \left(1 - \frac{s}{\omega_0}\right)$
+20dB/decade
$2f_0$
f_0
1dB
$0.5f_0$
3dB
0dB
1dB
$\| G(j\omega) \|_{dB}$
0°
$f_0 / 10$
5.7°
$\angle G(j\omega)$
-45°/decade
-45°
f_0
-90°
5.7°
$10 f_0$

Inverted Pole



Inverted Zero