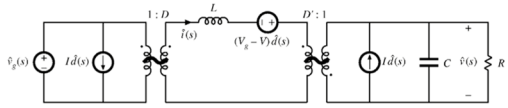
Control-to-Output TF



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Numerical Example

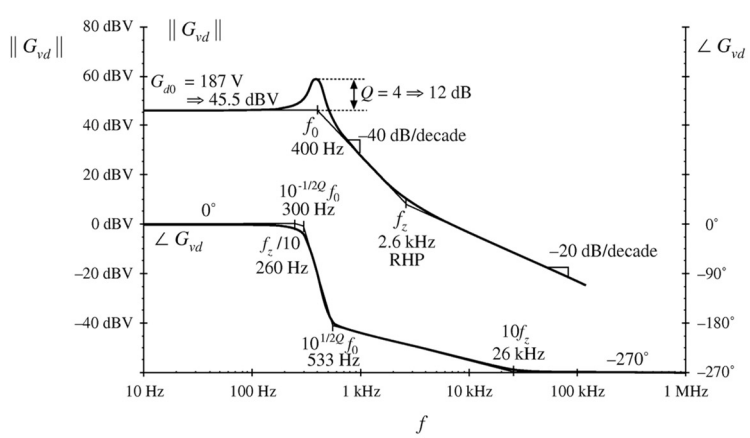
Suppose we are given the following numerical values:

$$D = 0.6$$
$$R = 10\Omega$$
$$V_g = 30\text{V}$$
$$L = 160\mu\text{H}$$
$$C = 160\mu\text{F}$$

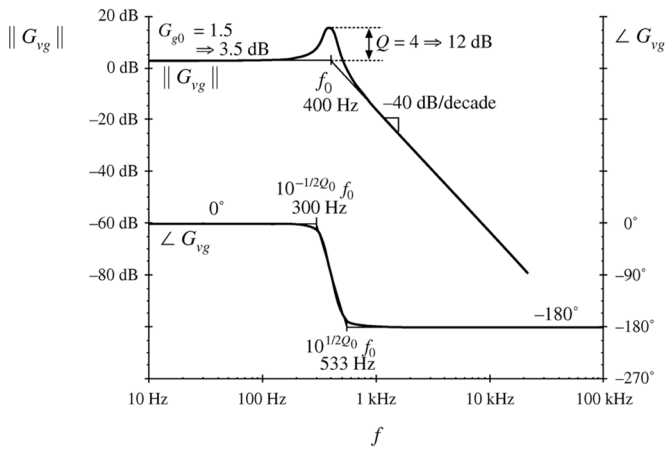
Then the salient features have the following numerical values:

$$|G_{g0}| = \frac{D}{D'} = 1.5 \Rightarrow 3.5 \text{ dB}$$
$$|G_{d0}| = \frac{|V|}{DD'} = 187.5 \text{ V} \Rightarrow 45.5 \text{ dBV}$$
$$f_0 = \frac{\omega_0}{2\pi} = \frac{D'}{2\pi\sqrt{LC}} = 400 \text{ Hz}$$
$$Q = D'R\sqrt{\frac{C}{L}} = 4 \Rightarrow 12 \text{ dB}$$
$$f_z = \frac{\omega_z}{2\pi} = \frac{D'^2 R}{2\pi DL} = 2.65 \text{ kHz}$$

G_{vd} Bode Plot



G_{vg} Bode Plot



TFs of Some Basic Converters

Table 8.2. Salient features of the small-signal CCM transfer functions of some basic dc-dc converters

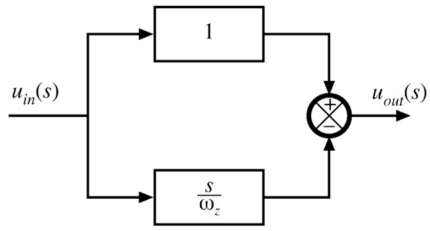
Converter	G_{g0}	G_{d0}	ω_0	Q	ω_z
buck	D	$\frac{V}{D}$	$\frac{1}{\sqrt{LC}}$	$R\sqrt{\frac{C}{L}}$	∞
boost	$\frac{1}{D'}$	$\frac{V}{D'}$	$\frac{D'}{\sqrt{LC}}$	$D'R\sqrt{\frac{C}{L}}$	$\frac{D'^2R}{L}$
buck-boost	$-\frac{D}{D'}$	$\frac{V}{D\,D'^2}$	$\frac{D'}{\sqrt{LC}}$	$D'R\sqrt{\frac{C}{L}}$	$\frac{D'^2R}{D\,L}$

where the transfer functions are written in the standard forms

$$G_{vd}(s) = G_{d0}\frac{\left(1-\frac{s}{\omega_z}\right)}{\left(1+\frac{s}{Q\omega_0}+\left(\frac{s}{\omega_0}\right)^2\right)} \qquad G_{vg}(s) = G_{g0}\frac{1}{1+\frac{s}{Q\omega_0}+\left(\frac{s}{\omega_0}\right)^2}$$

Origins of RHP Zero

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

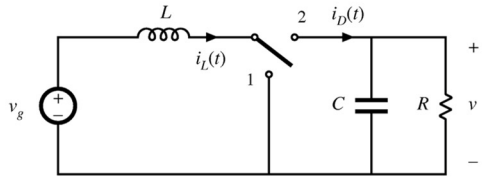


- *phase reversal at high frequency*
- *transient response: output initially tends in wrong direction*

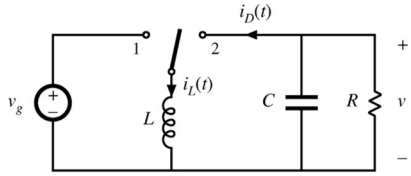
CCM RHP Zero

$$\langle i_D \rangle_{T_s} = d' \langle i_L \rangle_{T_s}$$

Boost



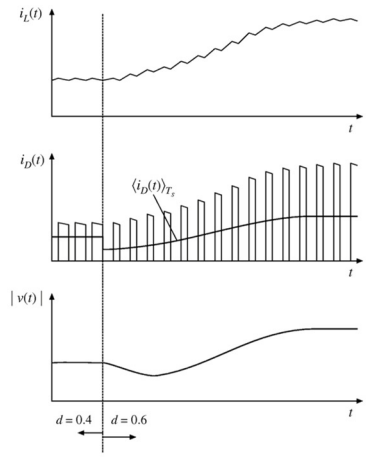
Buck-boost



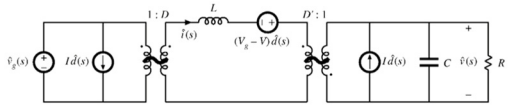
Waveforms of Step Change in *d*

$$\langle i_D \rangle_{T_s} = d' \langle i_L \rangle_{T_s}$$

- Increasing $d(t)$ causes the average diode current to initially decrease
- As inductor current increases to its new equilibrium value, average diode current eventually increases



Output Impedance



Graphical Construction of Bode Plots

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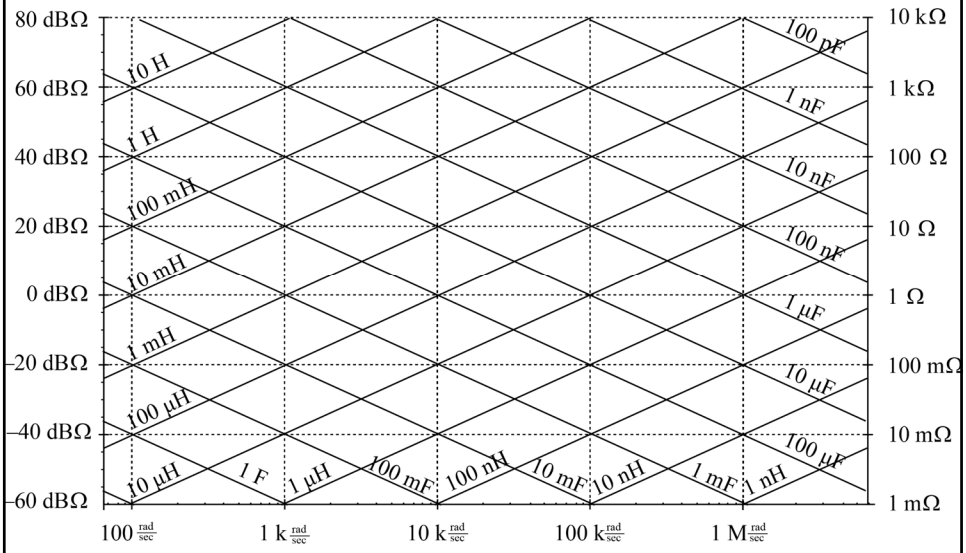

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