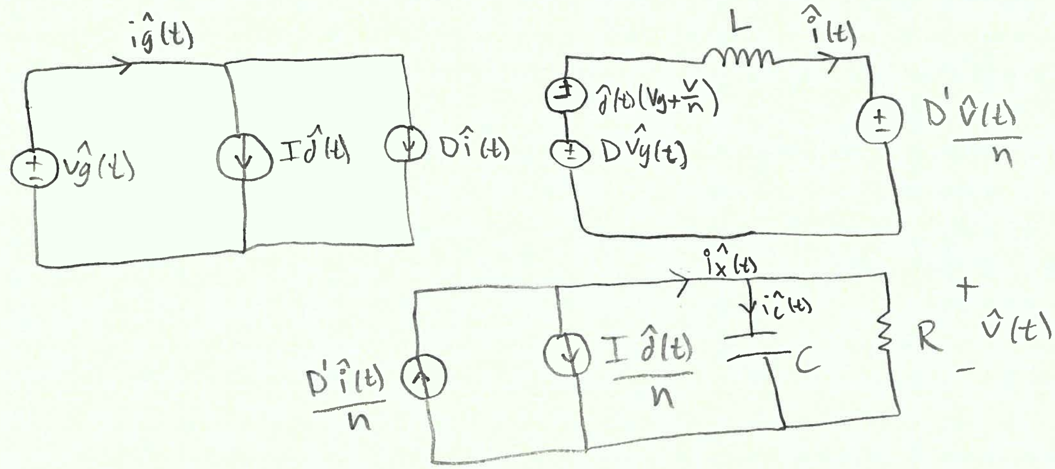
a) Small signal model of flyback "Fig 7.26 Ron≈0"



$$Z_n(s) = \left.\frac{\hat{v}_{test}(s)}{i_{test}(s)}\right|_{\hat{v}\xrightarrow[null]{}0}$$

if $\hat{v}\xrightarrow[null]{}0$, then the current through parallel output impedance (R||C) must be zero. This means $\hat{i}_x(s)=0$. We can do a

KCL

$$\frac{D'\hat{i}(s)}{n} = \frac{I\hat{d}(s)}{n} + \cancelto{0}{\hat{i_x}(s)}$$

$$\frac{D'\hat{i}(s)}{n} = \frac{I\hat{d}(s)}{n} \quad (1)$$

$$\hat{i_g}(s) = \hat{i}_{test}(s) = I\hat{d}(s) + D\hat{i}(s) \quad (2)$$

KVL

$$-D\hat{v_g}(s) + sL\hat{i}(s) + \cancelto{0\ null}{\frac{D'\hat{v}(s)}{n}} = \hat{d}(s)\left(V_g+\frac{V}{n}\right)$$

$$-D\hat{v_g}(s) + sL\hat{i}(s) = \hat{d}(s)\left(V_g+\frac{V}{n}\right)$$

$$\hat{v_g}(s) = \hat{v}_{test}(s)$$

$$-D\hat{v}_{test}(s) + sL\hat{i}(s) = \hat{d}(s)\left(V_g+\frac{V}{n}\right) \quad (3)$$

Solve (1)-(3) for $\hat{v}_{test}(s)$, $\hat{i}(s)$, $\hat{d}(s)$

$$Z_n(s) = \left.\frac{\hat{v}_{test}(s)}{\hat{i}_{test}(s)}\right|_{\hat{v}\xrightarrow[null]{}0} = \boxed{\frac{sLnI - D'V_gn - D'V}{DnI(D'+D)}}$$

a cont)

$$Z_n(s) = \frac{sLnI - D'V_g n - D'V}{DnI(D'+D)}$$

$$Z_n(s) = \frac{sLnI - D'(V_g n + V)}{DnI}$$

DC operating pts

$$I = \frac{nV}{D'R} = 1.4694\,A$$

$$V = \frac{DV_g n}{D'} = 10.2857\,V$$

$$Z_D(s) = \left.\frac{\hat{v}_{test}(s)}{\hat{i}_{test}(s)}\right|_{\hat{d}(s)=0} \qquad \hat{v_g}(s) = \hat{v}_{test}(s)$$

KVL

$$-D\hat{v}_{test}(s) + sL\hat{i}(s) + \frac{D'\hat{v}(s)}{n} = 0 \quad (1)$$

$$\hat{i_g}(s) = \hat{i}_{test}(s) = D\hat{i}(s) \quad (2)$$

KCL

$$\frac{D'\hat{i}(s)}{n} = \frac{I\hat{d}(s)}{n} + \hat{i_x}(s)$$

$$\frac{D'\hat{i}(s)}{n} = \hat{i_x}(s) \quad (3)$$

$$\hat{i_x}(s) = \frac{\hat{v}(s)}{\frac{1}{sC}} + \frac{\hat{v}(s)}{R}$$

Solve (1)-(4) for $\hat{v}_{test}(s)$, $\hat{i}(s)$, $\hat{i_x}(s)$, $\hat{v}(s)$

$$Z_D(s) = \frac{s^2Ln^2RC + sLn^2 + R - 2DR + D^2R}{D^2n^2(sCR+1)}$$

(b1) Design filter for at least 100dB at the switching frequency

From Notes 5

$$\|G\| = \left(\frac{f}{f_f}\right)^n$$

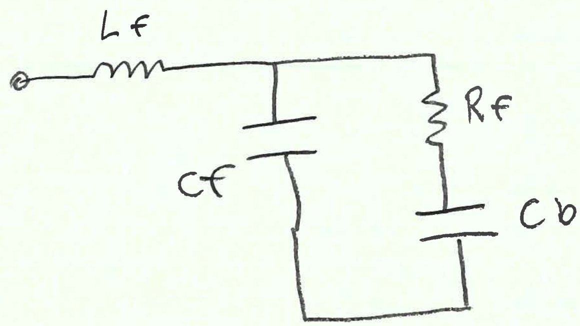
$$\|G\| = 10^{\left(\frac{-100}{20}\right)} = 1e^{-5} \quad , \; n = -2 \text{ "-40dB/decade"}$$

We want $-100dB$ at $f = 200kHz$

$$1e^{-5} = \left(\frac{200000}{f_f}\right)^{-2}$$

solve for required corner f_f

$$f_f \leq 632.45 \; Hz$$



We know $f_f = \dfrac{1}{2\pi\sqrt{L_f C_f}}$

choose $\underline{\underline{C_f = 3 \times 47\mu F}}$ "AVX Turbo cap"

required $\underline{\underline{L_f = 449.12 \mu H}}$

bii) Choose $\|Z_o(j\omega)\|$ to equal the worst case of $\|Z_D(j\omega)\|$ and $\|Z_N(j\omega)\|$

from the Bode plots, worst case "minimum" impedance occurs at $\|Z_D(j2\pi 1.4e3)\| \approx 14.7\,dB$

$$14.7\,dB = 5.43\,\Omega$$

set $\|Z_o(j2\pi f_f)\| = (0.3)(5.43) = \|Z_o\|_{mm}$

↑ resonant frequency

$$\|Z_{omm}\| = 1.6298\,\Omega$$

(10,30) from Erickson

$$n = \frac{R_{of}^2}{\|Z_{omm}\|^2}\left(1 + \sqrt{1 + 4\frac{\|Z_{omm}\|^2}{R_{of}^2}}\right)$$

Recall $R_{of} = \sqrt{\frac{L_f}{C_f}}$

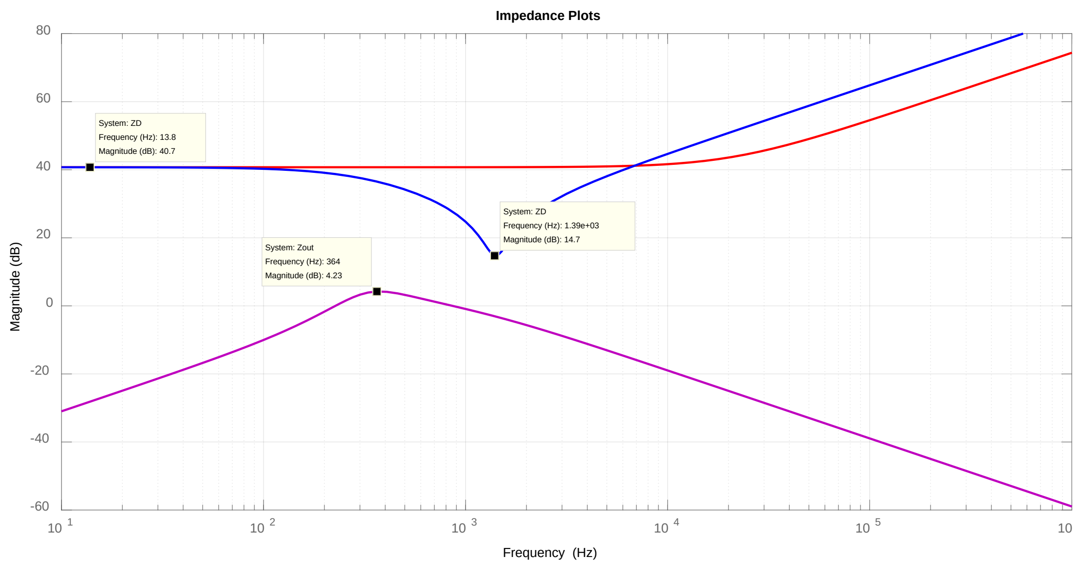
$$\underline{\underline{n \approx 3.6962}}$$

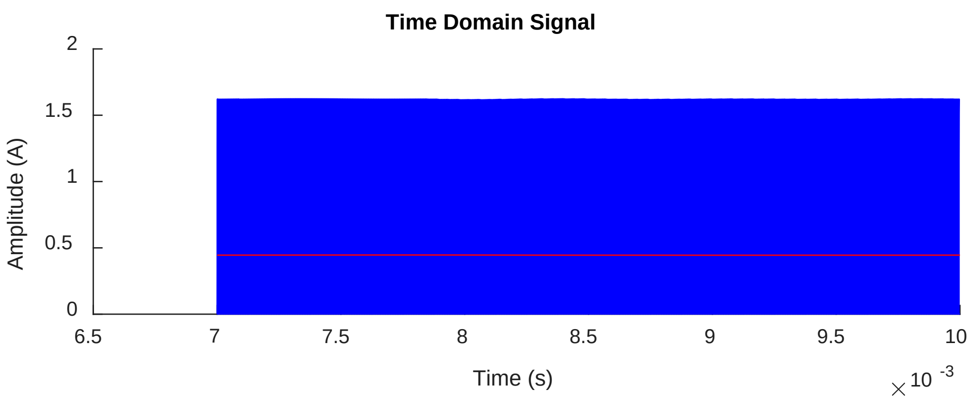
$$C_b = C_f\, n$$

$$\underline{\underline{C_b = 521.17\,\mu F}}$$ "electrolytic type"

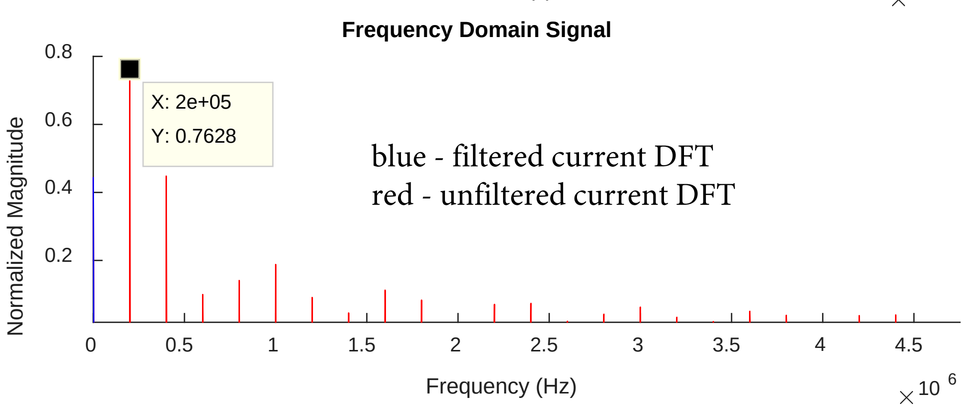
$$R_f = R_{of}\sqrt{\frac{(2+n)(4+3n)}{2n^2(4+n)}}$$

$$\underline{\underline{R_f = 1.1410\,\Omega}}$$





blue - unfiltered current
red - filtered current



blue - filtered current DFT
red - unfiltered current DFT