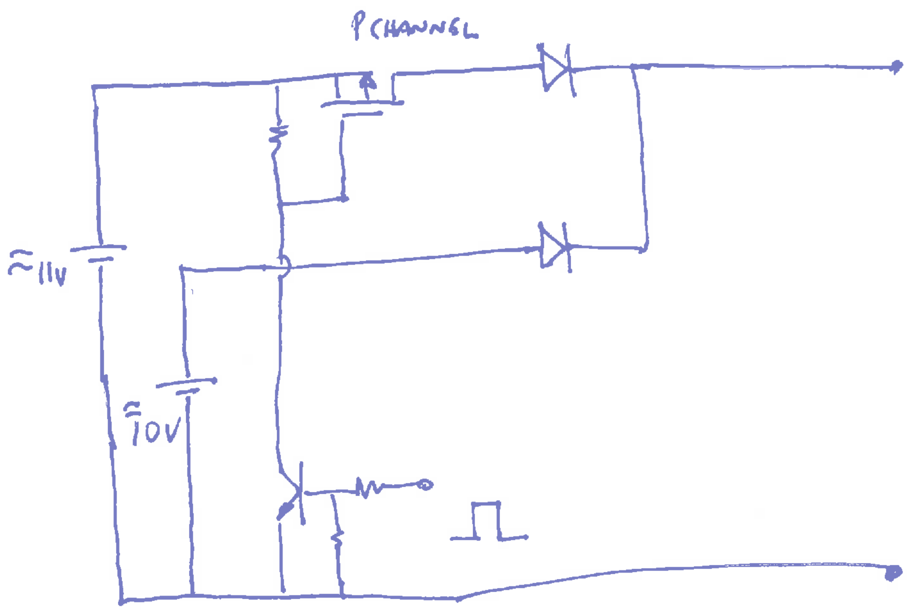
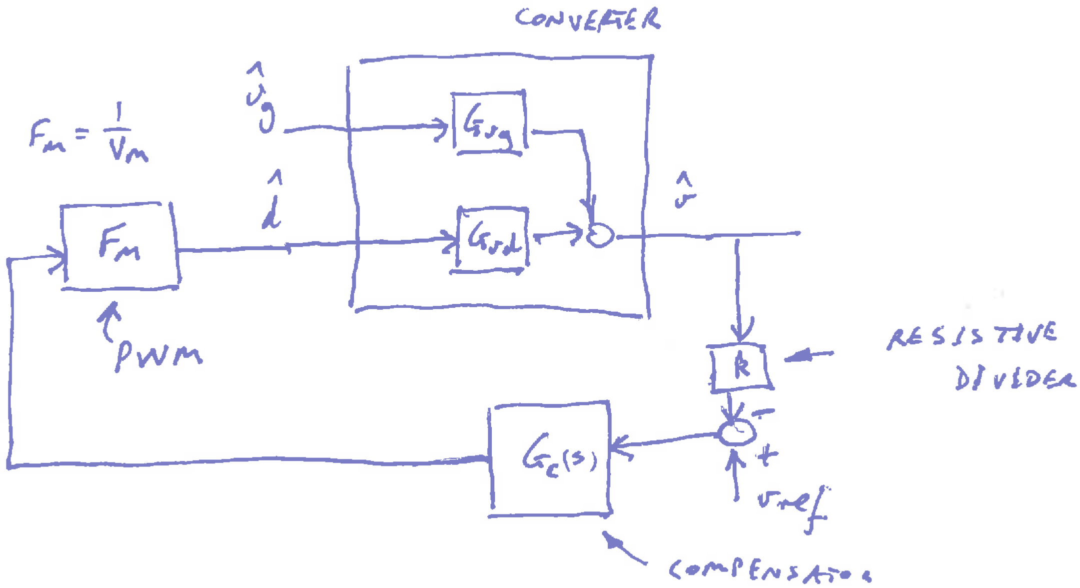
SWITCHING CIRCUIT

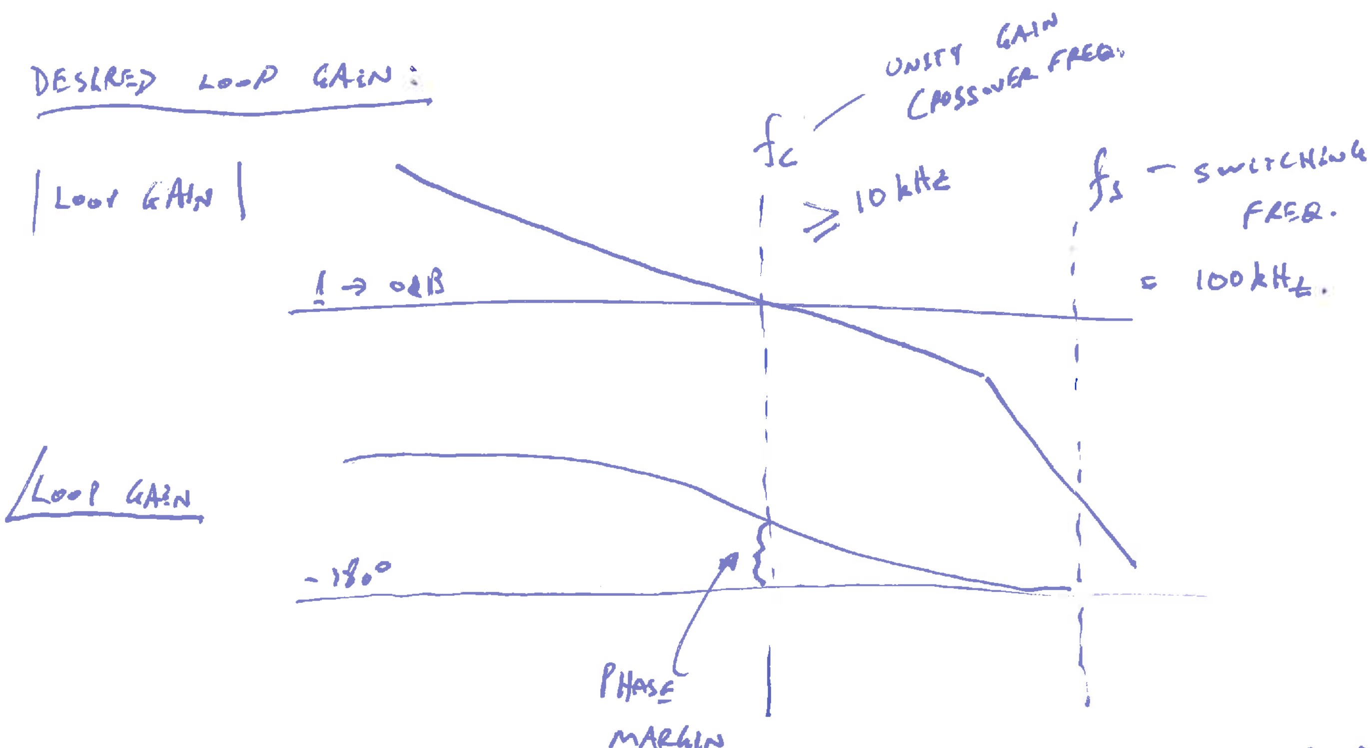




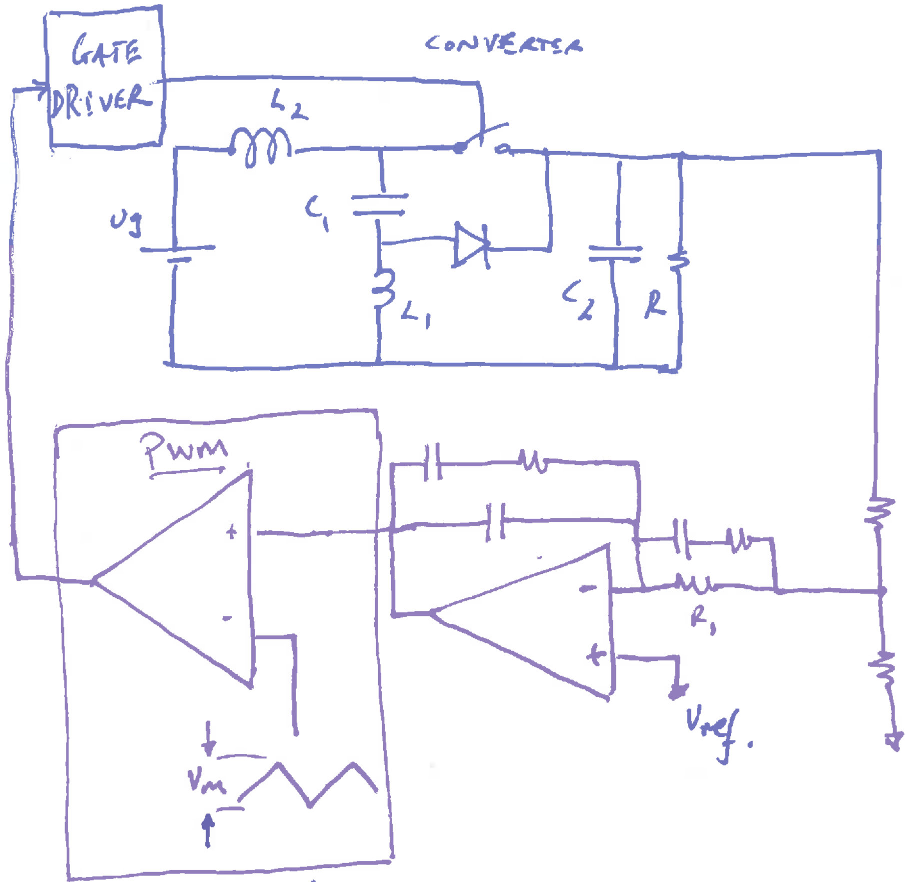
$$\frac{\hat{v}}{\hat{v}_g} = \frac{G_{vg}}{1 + k G_c F_m G_{vd}}$$

$$\text{LOOP GAIN} = k\, G_c\, F_m\, G_{vd}.$$

DESIRED LOOP GAIN:



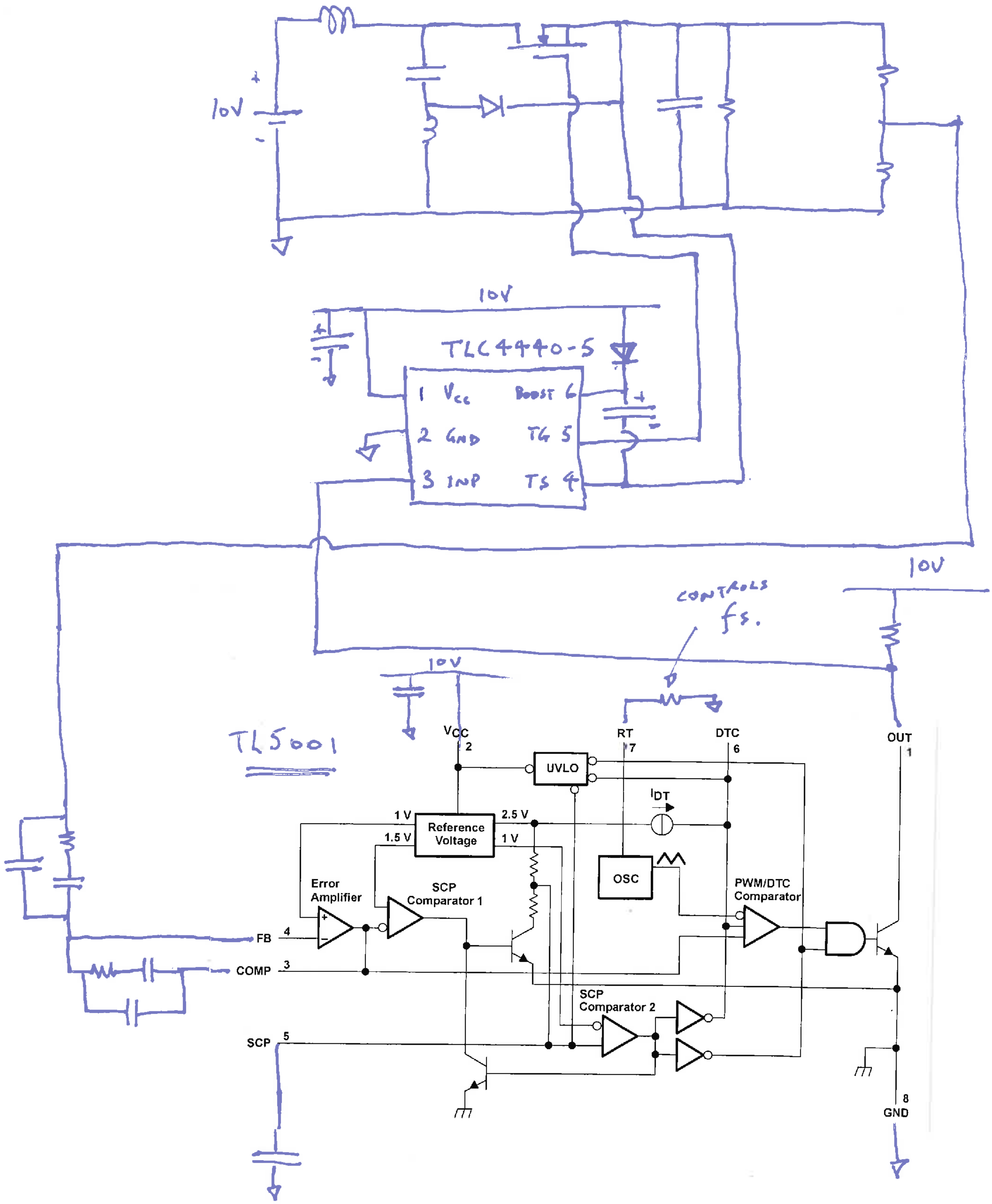
WE WANT PHASE MARGIN ≈ 60°.



$$F_m = \frac{1}{V_m}$$

$$\left.\begin{aligned} V_{MAX} &= 1.3 \\ V_{MIN} &= 0.7 \end{aligned}\right\} \Rightarrow V_m = 1.3 - 0.7 = \underline{0.6\ V}$$

4


10V
TLC4440-5
1 Vcc
Boost 6
2 GND
TG 5
3 INP
TS 4
10V
controls fs.
TL5001
Vcc
2
RT
7
DTC
6
OUT
1
UVLO
IDT
1 V
2.5 V
1.5 V
Reference Voltage
1 V
OSC
Error Amplifier
SCP Comparator 1
PWM/DTC Comparator
FB
4
COMP
3
SCP Comparator 2
SCP
5
8
GND

INPUT INDUCTOR FOC (C1): INCLUDING PARASITIC RESISTANCES

$$\frac{\hat{v}}{\hat{d}}(s) = G_{vd}(s) = \frac{V_g\left[s^2(L_1+L_2)C_1 + s\,\dfrac{D(D'L_2 - DL_1)}{R} + 1\right]}{\left[(L_1+L_2)C_1 s^2 + \dfrac{D'^2 L_2}{R}s + 1\right]\left[(L_1 \| L_2)C_2 s^2 + \dfrac{L_1}{R}s + 1\right]}$$

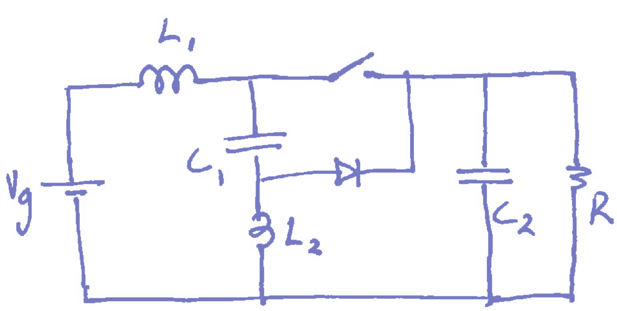
$$\boxed{sL_x \longrightarrow sL_x + r_{L_x}} \qquad x = 1, 2$$

$$\frac{1}{sC_x} \longrightarrow \frac{1}{sC_x},\ r_{C_x} \qquad = \frac{1}{sC_x} + r_{C_x} = \frac{1 + s r_x C_x}{sC_x}.$$

$$\therefore \quad \boxed{sC_x \longrightarrow \frac{sC_x}{1 + s r_x C_x}.}$$

$$= \frac{V_g\left[(sL_1 + r_{L_1})\left(\dfrac{sC_1}{1 + s r_{C_1} C_1}\right) + (sL_2 + r_{L_2})\left(\dfrac{sC_1}{1 + s r_{C_1} C_1}\right) + \dfrac{DD'(sL_2 + r_{L_2}) - D^2(sL_1 + r_{L_1})}{R} + 1\right]}{\text{DENOMINATOR}}$$

INPUT INDUCTOR FOC:



NOTE: L_1 AND L_2 ARE INTERCHANGED COMPARED TO A PREVIOUS SCHEMATIC THAT I HANDED OUT.

NUMERATOR:

$$= V_g \left[\frac{s^2 L_1 C_1}{1+s r_{c_1} C_1} + \frac{s r_{L_1} C_1}{1+s r_{c_1} C_1} + \frac{s^2 L_2 C_1}{1+s r_{c_1} C_1} + \frac{s r_{L_2} C_1}{1+s r_{c_1} C_1} \right.$$

$$\left. + \frac{D D' s L_2}{R} + \cancel{\frac{D D' r_{L_2}}{R}} - \frac{D^2 s L_1}{R} - \cancel{\frac{D^2 r_{L_1}}{R}} + 1 \right]$$

IGNORE SINCE $\frac{r_{L_2}}{R} \ll 1$ and $\frac{r_{L_1}}{R} \ll 1$

$$= V_g \left[\frac{1}{1+s r_{c_1} C_1} \left\{ s^2 (L_1 + L_2) C_1 + s (r_{L_1} + r_{L_2}) C_1 + s \frac{D(D' L_2 - D L_1)}{R} (1 + s r_{c_1} C_1) + 1 + s r_{c_1} C_1 \right\} \right]$$

$$= V_g \left[\frac{1}{1+s r_{c_1} C_1} \left\{ s^2 \left[(L_1 + L_2) C_1 + \frac{D(D' L_2 - D L_1) r_{c_1} C_1}{R} \right] + s \left[r_{c_1} C_1 + (r_{L_1} + r_{L_2}) C_1 + \frac{D(D' L_2 - D L_1)}{R} \right] + 1 \right\} \right]$$

DENOMINATOR FACTOR 1:

$$(L_1+L_2)C_1 s^2 + \frac{D'^2 L_2}{R} s + 1$$

$$\rightarrow \frac{1}{1+s r_{c_1} C_1}\left\{ s^2\left[(L_1+L_2)C_1 + \frac{D'^2 L_2}{R} r_{c_1} C_1\right] + s\left[r_{c_1}C_1 + (r_{L_1}+r_{L_2})C_1 + \frac{D'^2 L_2}{R}\right] + 1\right\}$$

DENOMINATOR FACTOR 2:

$$\underbrace{(L_1 \| L_2)}_{L_e} C_2 s^2 + \frac{L_1}{R} s + 1$$

$$\rightarrow \frac{1}{1+s r_{c_2} C_2}\left\{ s^2\left[L_e C_2 + \frac{L_1}{R} r_{c_2} C_2\right] + s\left[r_{c_2} C_2 + r_{L_e} C_2 + \frac{L_1}{R}\right] + 1\right\}$$

$G_{vd}(s)$ WITH PARASITIC RESISTANCES INCLUDED: FINAL RESULT

$$G_{vd}(s) = \frac{\left(1 + s r_{C_2} C_2\right)\left[s^2\left\{(L_1+L_2)C_1 + \frac{D\left(D'L_2 - DL_1\right) r_{C_1} C_1}{R}\right\} + s\left\{\left(r_{C_1} + r_{L_1} + r_{L_2}\right) C_1 + \frac{D\left(D'L_2 - DL_1\right)}{R}\right\} + \right.}{\left\{ s^2\left[(L_1+L_2)C_1 + \frac{D'^2 L_2 r_{C_1} C_1}{R}\right] + s\left[\left(r_{C_1} + r_{L_1} + r_{L_2}\right) C_1 + \frac{D'^2 L_2}{R}\right] + 1 \right\} \cdot \left\{ s^2\left(L_e C_2 + \frac{L_1}{R} r_{C_2} C_2\right) + s\left(\left(r_{C_2} + r_{L_e}\right) C_2 + \frac{L_1}{R}\right) + 1 \right\}}.$$

CONCLUSIONS:

1) THE RESONANT FREQS. (ω_n) ARE LARGELY UNCHANGED (GIVEN THAT r_{C_1}, r_{C_2}, r_{L_1} and $r_{L_2} \ll R$.)

2) Q'S MAY BE ALTERED SOMEWHAT

3) THE MAIN EFFECT IS THE APPEARANCE OF A ZERO IN THE TRANSFER FUNCTION. THIS ZERO IS DUE TO THE ESR OF THE OUTPUT CAPACITOR. $f_{ZERO} = \frac{1}{2\pi r_{C_2} C_2}$.

NOTE: A SYSTEM THAT FEATURES A PAIR OF COMPLEX POLES CAN BE EXPRESSED IN POLYNOMIAL FORM AS

$$\left(\frac{s}{\omega_n}\right)^2 + \frac{s}{Q\omega_n} + 1$$

ω_n IS THE UNDAMPED NATURAL FREQ. (I ALSO REFER TO IT AS THE RESONANT FREQ ABOVE)

Q IS THE Q FACTOR, $Q = \frac{1}{2\zeta}$ WHERE ζ IS THE DAMPING RATIO.