EE414 HW Assignment #5

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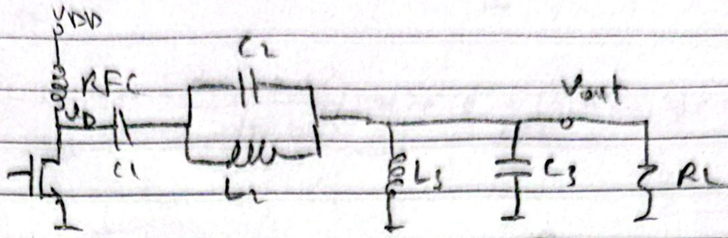
Question 1)



a) $R_{series2} = \frac{w_0 L_2}{Q_2} = \frac{2\pi \times 300MHz \times 50nH}{125} = \boxed{0.75\,\Omega}$ equivalent series resistance of L_2

$R_{parallel_2} = Q_2 \times w_0 L_2 = \boxed{11,780.97\,\Omega \approx 11,781\,\Omega}$ equivalent parallel resistance of L_2

b) $R_{series3} = \frac{w_0 L_3}{Q_3} = \frac{2\pi \times 100MHz \times 22nH}{90} = \boxed{0.154\,\Omega}$ eq. series resistance of L_3

$R_{parallel_3} = Q_3 \times w_0 L_3 = \boxed{1,244\,\Omega}$ eq. parallel resistance of L_3

c) Resonate at $3f_0 = 300MHz$

$w_0 = \frac{1}{\sqrt{LC}} \Rightarrow C_2 = \frac{1}{L_2 \times w_0^2} = \boxed{5.63\,pF}$

d) Resonate at $f_0 = 100MHz$

$w_0 = \frac{1}{\sqrt{LC}} \Rightarrow C_3 = \frac{1}{L_3 \times w_0^2} = \boxed{115.14\,pF}$

e) $X_C = \frac{1}{C \cdot w_0} = \frac{R_L}{20} = 2.5\,\Omega$

$C_1 = \frac{1}{2.5 \times 2\pi \times 100MHz} = \boxed{636.62\,pF}$

$X_L = w_0 L = 15 R_L = 750\,\Omega$

$L_{RFC} = \frac{750}{w_0} = \frac{750}{2\pi \times 100MHz} = 1.19\,\mu H$

f) $R_2 + (R_L // R_{3p}) = \frac{9}{8} \frac{(V_{DD} - V_{SAT})}{I_1}$

$R_2 = 0.75\,\Omega$
$R_L = 50\,\Omega$
$R_{3p} = 1244\,\Omega$

$R_2 + (R_L // R_{3p}) = 0.75 + \frac{50 \times 1244}{50 + 1244} = 48.82\,\Omega$

$I_1 = \frac{I_{max}}{2\pi(1-\cos\frac{\alpha}{2})}(\alpha - \sin\alpha) = \boxed{\frac{I_{max}}{2}}$

$\hookrightarrow 48.82 = \frac{9}{8} \frac{(28-1)}{0.5 I_{max}} \Rightarrow 0.5 I_{max} = \frac{9}{8} \cdot \frac{27}{48.82}$

$\boxed{\Rightarrow I_{max} = 1.244\,A}$

g) $\sin\gamma = \frac{3\pi \cdot (28-1)}{8 \times 11.784 \times 1.244} = 2.17 \times 10^{-3} \Rightarrow \boxed{\gamma = 0.124^\circ}$

$\alpha = \pi + 0.124^\circ \Rightarrow \alpha = 180.124^\circ = 3.1438$ rad $\quad (\alpha \approx \pi)$

h) $I_0 = \frac{I_{max}}{2\pi} \frac{2\sin\frac{\alpha}{2} - \cos\frac{\alpha}{2}}{1-\cos\frac{\alpha}{2}} = \boxed{0.396\,A \quad \text{where} \quad \alpha = \pi + \gamma}$

i) $I_1 = \frac{I_{max}}{2} = 0.622\,A$

$R_{Lopt} = \frac{9}{8} V_{DD} \cdot \frac{1}{I_1} = 48.82\,\Omega$

$P_{out} = \left(\frac{9}{8} V_{DD}\right)^2 \cdot \frac{1}{2} \cdot \frac{1}{R_{Lopt}} = 9.45\,W$

$P_{RL} = \frac{V_p^2}{2} \cdot \frac{1}{R_L} \Rightarrow V_p = I_1 \times (R_L // R_{3p}) = 29.9\,V$

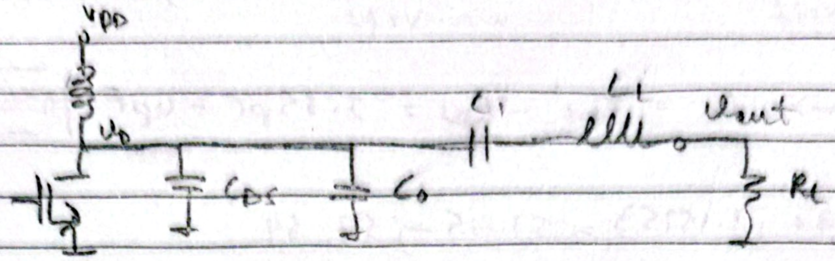
$\hookrightarrow P_{RL} = \frac{29.9^2}{2} \cdot \frac{1}{50} = \boxed{8.94\,W}$

j) $P_{DC} = V_{DD} \times I_0 = 28 \times 0.396 = \boxed{11.088\,W}$

$\eta = 80.63\%$

η is higher than class B, which is at max. 78.5%

Question 2)



$f_0 = 100\,MHz$ $\quad C_{DS} = 4pF$ $\quad R_L = 50\,\Omega$ $\quad V_{DD} = 24V$

a) $X_L = 15 R_L$ at f_0

$X_L = 750\,\Omega$

$X_L = w_0 L \Rightarrow L_{RFC} = \frac{X_L}{w_0} = \frac{750}{2\pi \times 100MHz} = \boxed{1.19\,\mu H}$

1008AF - 132X-RC inductor is chosen, its inductance is $\boxed{1.3\,\mu H}$

reactance is $817\,\Omega$, where as chosen reactance value is $750\,\Omega$

b) R_{2DC} is $\boxed{0.11\,\Omega}$, from the datasheet.

c) $\frac{w_0 L_1}{R_L} = Q \Rightarrow L_1 = \frac{Q \cdot R_L}{2\pi f_0}$ → for $Q=5 \Rightarrow L_1 = 398\,nH$

→ for $Q=10 \Rightarrow L_1 = 796\,nH$

2929SQ - 501 - EL inductor is chosen, which has a value of $\boxed{500\,nH \text{ @ } 50MHz}$

d) Inductor's Q is 180 @ 50MHz. Using that information:

$\frac{w_0 L_1}{R_1} = Q \Rightarrow R_1 = \frac{w_0 L_1}{Q} = \frac{2\pi \times 100MHz \times 500nH}{180} = \boxed{1.75\,\Omega}$

e) $R_{Load\,effective} = R_1 + R_L = 51.75\,\Omega$

$V_{eff} = V_{DD} - I_{DC} R_{2DC} = 24 - 0.11\, I_{DC}$

↳ $R_{loadeff} = \frac{V_{eff}}{I_{DC}} \cdot \frac{8}{\pi^2+4} \Rightarrow I_{DC} = \frac{V_{eff}}{R_{load\,eff}} \cdot \frac{8}{\pi^2+4}$

$\boxed{\Rightarrow I_{DC} = 0.267\,A}$ using the solve function of the calculator.

f) $\omega C_{DS}' = \frac{I_{DC}}{\pi \cdot V_{eff}} \Rightarrow C_{DS}' = \frac{I_{DC}}{\omega \pi \cdot V_{eff}} = 5.65\,pF$

$C_{DS}' = C_{DS} + C_0 \rightarrow C_0 = C_{DS}' - C_{DS} = 5.65pF - 4pF = \boxed{1.65pF}$

g) $Z_L = R_{Loadeff}(1 + j1.1525) = 51.75 + j59.64$

Output reactance $= \underbrace{\omega_0 L_1}_{314.16} - \frac{1}{\omega_0 C_1} = 59.64$

$\rightarrow \omega_0 C_1 = \frac{1}{254.52} \Rightarrow C_1 = \frac{1}{\omega_0 \times 254.52} = \boxed{6.25pF}$

h) $P_{out} = V_{eff} \times I_{DC} = 6.4W$

But power delivered to load is different:

$P_L = P_{out} \times \frac{R_L}{R_L + R_1} = \boxed{6.18W}$ $\Big\}$ $\boxed{\eta = 96.44\%}$

i) $P_{DC} = V_{DD} \times I_{DC} = 6.408W$

j) $V_p = 3.56 \times V_{eff} = \boxed{85.34V}$

k) $I_p = 2.86 \times I_{DC} = \boxed{0.764\ A}$