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Sp '09

Problem Set 11 Solution

EE 239

1. Problem 12.6 At 50 mTorr, $n_g = 1.65 \times 10^{15}$ cm^{-3}

Then $\lambda_i = 1/330p = 0.061$ cm; $h_\ell = 0.067$ and $h_R = 0.062$. From (10.2.13), $d_{eff} = 52.8$ cm. From Fig. 10.11 with $n_g d_{eff} = 8.7 \times 10^{20}$ m^{-2}, $T_e = 1.83$ V. From Fig. 3.17, $\mathcal{E}_c = 158$ V. Then $\mathcal{E}_T = 7.2 T_e + \mathcal{E}_c$ or $\mathcal{E}_T = 171$ V. Also, $u_B = 2.1 \times 10^5$ cm/s, and $A_{eff} = 119$ cm^2. Then from (10.2.15), we find $n_0 = 8.8 \times 10^{11}$ cm^{-3}. We estimate

$n_{sR} = h_R n_0 = 5.4 \times 10^{10}$ cm^{-3}. From Fig 3.16, $K_m = 4.1 \times 10^{-8}$ cm^3/s and $\nu_m = K_m n_g = 6.8 \times 10^7$ s^{-1}. Since $\omega = 8.5 \times 10^7$ s^{-1}, ν_m is not really large compared to ω, as stated in the problem, but we will assume $\nu_m \gg \omega$ and use the collisional skin depth (12.1.16). The dc conductivity is $\sigma_{dc} = e^2 n_{sR} / m\nu_m = 22.5$ S/m. Then $\delta_c = 2.9$ cm. (The more accurate result from (12.1.1) gives $\delta = 2.7$ cm.) Continuing, from (12.1.21), we find $R_s = 43.6\ \Omega$ and, from (12.1.20), $L_s = 2.2\ \mu$H. Then $X_s = \omega L_s = 190\ \Omega$. Calculating the matching network parameters (p. 469-470) yields $C_1 = 68$ pF and $C_2 = 90$ pF.

The coil current and voltage from (12.1.22) and (12.1.23) are $I_{rf} = 5.25$ A and $V_{rf} = 1020$ V.

2. Problem 12.9

From (12.2.3) $P_{abs} = \frac{1}{2} I_{rf}^2 \frac{\pi e^2 n_0 V_{eff} M_0^2 N^2 R^4}{8 m l}$

From (10.2.14) $P_{loss} = e n_0 u_B A_{eff} \mathcal{E}_T$

Equating these and solving for $I_{rf} = I_{min}$ we obtain

$$I_{min} = \left[\frac{16 m l u_B A_{eff} \mathcal{E}_T}{\pi e V_{eff} M_0^2 N^2 R^4} \right]^{1/2} \quad //$$

Putting in the numbers yields

$$I_{min} = 1.05 \text{ A} \quad //$$