

Gate Assignment

EE:1205 Signals and Systems
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Question: A Spectrometer is used to detect plasma oscillations in a sample. The spectrometer can work in the range of $3 \times 10^{12} \text{ rad s}^{-1}$ to $30 \times 10^{12} \text{ rad s}^{-1}$. The minimum carrier concentration that can be detected by using this spectrometer is $n \times 10^{21} \text{ m}^{-3}$. The value of n is _____. (Round off to two decimal places)

(Charge on electron = $-1.6 \times 10^{-19} \text{ C}$, mass of electron = $9.1 \times 10^{-31} \text{ kg}$ and $\epsilon_0 = 8.85 \times 10^{-12} \text{ C}^2 \text{ N}^{-1} \text{ m}^{-2}$)

Solution:

Parameter	Value	Description
ω_{p1}	$3 \times 10^{12} \text{ rad s}^{-1}$	Lower bound of plasma frequency
ω_{p2}	$30 \times 10^{12} \text{ rad s}^{-1}$	Upper bound of plasma frequency
$\Delta\omega_p = \omega_{p2} - \omega_{p1}$	$27 \times 10^{12} \text{ rad s}^{-1}$	Plasma Frequency
n_0	$n \times 10^{21}$	Minimum carrier concentration
e	-1.6×10^{-19}	Charge on electron
m	9.1×10^{-31}	Mass of electron

TABLE 1
PARAMETER TABLE

$$\Delta\omega_p = \sqrt{\frac{n_0 e^2}{m \epsilon_0}} \quad (1)$$

$$\Rightarrow n_0 = \frac{(\Delta\omega_p)^2 m \epsilon_0}{e^2} \quad (2)$$

$$n_0 = \frac{(27 \times 10^{12})^2 \times (9.1 \times 10^{-31}) \times (8.85 \times 10^{-12})}{(-1.6 \times 10^{-19})^2} \quad (3)$$

$$\therefore n_0 = 2.83 \times 10^{21} \text{ m}^{-3} \quad (4)$$

$$n = n_0 \times 10^{-21} \quad (5)$$

$$\therefore n = 2.83 \quad (6)$$