For an N-MOS common-gate amplifier with $g_m = 5 \text{mS}$, $R_D = 5 \text{k}Q$, $R_s = 2 \text{k}Q$, $R_{SG} = 10 \text{k}Q$, we have:

$$R_m = \frac{1}{g_m} = \frac{1}{5} \text{M}$$

From Eq. 4.106b, we know that the overall voltage gain of this amplifier is:

$$G_v = \frac{g_m (R_D R_{SG})}{1 + g_m R_{SG}} = \frac{5 \times (5 \times 12 \times 10^3)}{1 + 5 \times 12} = 3.57 \text{V/V}$$

If we increase the bias current by a factor of 4, while maintaining the other parameter constants (assuming linear operation), we have:

$$g_m = 2 \times 12 \times 10 \text{mA/V}$$
$$R_m = \frac{1}{g_m} = 0.1 \text{k}O$$
$$G_v = \frac{3 \times 12 \times 100 \text{mA}}{1 + 3 \times 100} = 10 \times \frac{5 \times (5 \times 12 \times 10^3)}{1 + 3 \times 100} = 4.76 \text{V/V}$$

$$A_{v0} = 0.98 V_{10} \text{ and } A_v = 0.98 \times 0.49 V \text{ for } R_s = 50 \Omega$$

Eq. 4.102a: $A_v = \frac{R_s}{R_L}$, so $A_v = 0.49 = \frac{0.5}{0.5}$, therefore:

$$g_m = 1.92 \text{mA/V}$$

Eq. 4.103: $A_{v0} = \frac{R_s}{R_L}$, so $A_{v0} = 0.49 = \frac{R_s}{R_L}$

$$\Rightarrow R_L = \frac{25.5 \text{k}O}{R_s}$$

$$A_{M} = -27 \text{V/V}, C_{SG} = 0.3 \text{pF}, C_{GD} = 0.1 \text{pF}$$

Common - Source configuration.

Eq. 4.127: $C_{in} = C_{GS} + C_{GD} (1 + g_m R'_L)$.

Also $A_{M} = -g_m R'_L$, therefore:

$$C_{in} = 0.3 + 0.1 \times (1 + 27) = 3.1 \text{pF}$$

Now, to find the range of $R_{SG}$, that results in 3-dB frequencies over 1 MHz, we use eq. 4.132: $f_n = \frac{1}{2\pi R_m R_{SG}}$

If we neglect $R_g$ effect then $R_{SG} \leq R_{GS}$.

$$f_n \times 10^9 = \frac{1}{2\pi R_m R_{SG}} \geq 10^9$$

$$\Rightarrow R_{SG} \geq 6.5 \text{M}$$

$$A_{M} = -\frac{R_G}{R_s} \text{, } R_{in} = 100 \text{k}Q$$

$$A_{M} = -100 \text{ (50kQ } \times 10^9\text{ )} = 5 \times 10^{-6} \text{ V/V}$$

Also $R_{in} = 100 \text{k}Q - R_G$

$$A_{M} = -100 \times 3 \times 10^9 \times 10^6 = -5.1 \text{ V/V}$$

$$f_n = \frac{1}{2\pi R_m R_{SG}} \text{ (Eq. 4.132)}$$

$$R_{SG} = \frac{R_s}{R_D} \text{, } R_D = 100 \text{k}Q \times 10^9 = 5 \text{k}Q$$

$$C_{in} = C_s + C_d (1 + g_m R'_L)$$

$$R'_L = R_D (R_D R_L) = 4.1 \text{k}Q$$

$$C_{in} = 1 + 0.2 \times (3.3 \times 10^9) = 3.66 \text{pF}$$

Now we can calculate $f_n$:

$$f_n = \frac{1}{2\pi R_m R_{SG}} = 870 \text{ MHz}$$

In order to double $f_n$, we have to either decrease $C_{in}$ (by reducing $R_{out}$) or reduce $R_{SG}$ by reducing $R_{in}$.

If we reduce $R_{out} = R_D R_L$:

$$f_n = \frac{C_{in}}{2 \times 6.66 \text{pF}} \Rightarrow \frac{C_{in}}{2 \times 6.66 \text{pF}} = 1.45 \text{ MHz}$$

Then to reduce $R_D = 100 \text{k}Q$ by 1.45 MHz, we have to reduce $R_D = R_D (R_D R_L)$ to 1.45 kHz or equivalently, reducing $R_D$ to 1.45 kHz. The new midband gain would be:

$$A_{M} = \frac{R_s}{R'_L} = \frac{6.1 \times 10^9 \times 1.27 \times 0.49}{R_D} \text{ (4.1)}$$

Gain is almost reduced by a factor of 2.

If we reduce $R_{in} = R_G:

$$f_n = \frac{R_{SG}}{2\pi R_m R_{SG}} \Rightarrow \frac{R_{SG}}{2\pi R_m R_{SG}} = 5 \times 10^{-6} \text{ V/V}$$

$$A_{M} = \frac{R_s}{R_G} \text{, } R_{in} = 100 \text{k}Q$$

$$A_{M} = 0.98 \text{V}$$

Therefore in order to double $f_n$ to 870 MHz, we have to reduce $R_{out} = R_D R_L$ to 1.45 kHz or equivalently, reducing $R_D$ to 1.45 kHz. The new midband gain would be:

$$A_{M} = \frac{R_s}{R_D} \text{, } R_{in} = R_G$$

Gain is almost reduced by a factor of 2.