2) Resistance Large Enough For Thermal Noise to be neglected (but Not amplifier noise)

$$K = \frac{I}{\sqrt{\Delta f}\left(\frac{(V_A^*)^2}{M^2}\left(\frac{4\pi^2}{3}(\Delta f)^2C^2\right) + \frac{(I_A^*)^2}{M^2} + 2eIF\right)}$$

Low (small) bandwidths ; amplifier noise current dominates

$$\Delta f \leq \Delta f_0 \triangleq \left(\frac{I_A^*}{V_A^*}\right)\frac{\sqrt{3}}{2\pi} \times \frac{1}{C}$$

$$\uparrow$$

$$R_A^*$$

Si FET $V_A^* \simeq 4nV/\sqrt{Hz}$ $I_A^* \simeq 10fA/\sqrt{Hz}$

$R_A^* \simeq 400k\Omega$ $(\Delta f)_0 = 140kHz$

Si BJT $V_A^* \simeq 2nV/\sqrt{Hz}$ $I_A^* \simeq 2pA/\sqrt{Hz}$

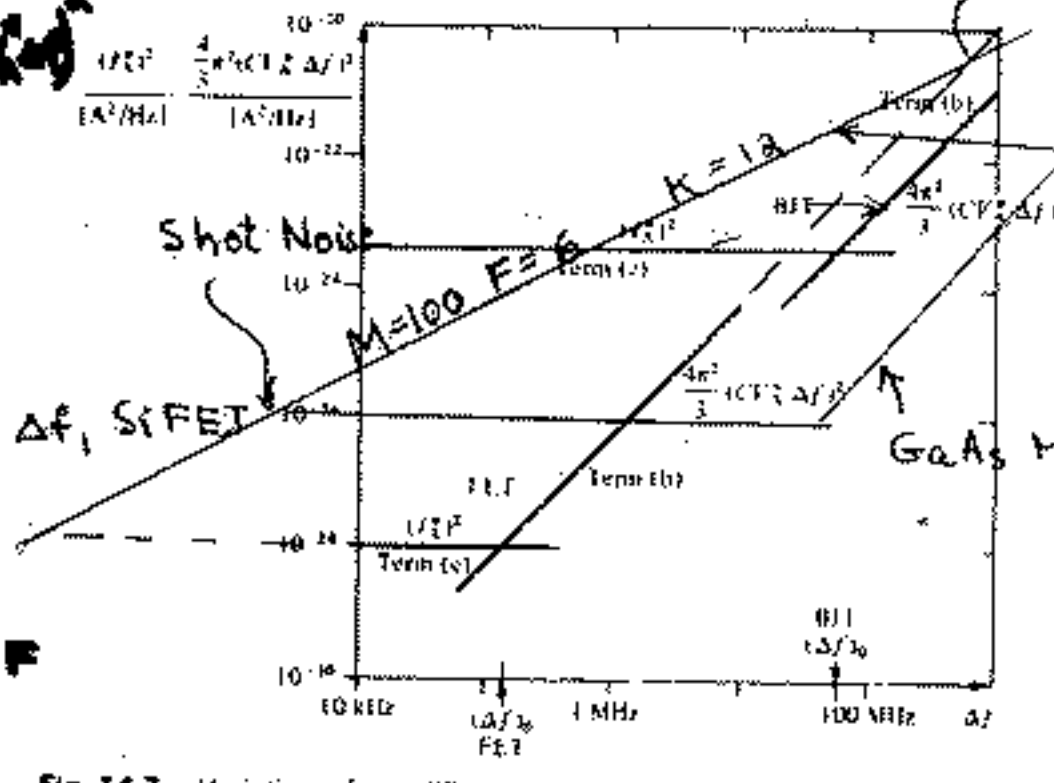
$R_A^* \simeq 1k\Omega$ $(\Delta f)_0 \simeq 55MHz$

GaAs MESFT

$V_A^* \simeq 1nV/\sqrt{Hz}$ $I_A^* \simeq .1pA/\sqrt{Hz}$

Δf_2 Si FET

$(I_A^*)^2$, $\frac{4}{3}\pi^2(CF)^2\Delta f^2$



Limit when

1) $K = \frac{I}{\sqrt{\Delta f}(2eIF)^{1/2}}$

2) $I = K^2 2eF\Delta f$

3) Shot Noise Term is then equal to $(2e(F)K)^2\Delta f$

C = 5pF

GaAs MESFET

Fig. 14.7 Variation of amplifier voltage and current noise sources with frequency in the high input resistance amplifier.

Expressions for Δf_1 and Δf_2

Shot Noise term is $(2eFK)^2\Delta f$

This dominates current Noise when

$$\Delta f > \Delta f_1 = \frac{(I_A^*)^2}{(2eMFK)^2}$$

The high frequency limit is obtained when the voltage Noise dominates

$$2eIM^2F > \frac{4\pi}{3}^2(\Delta f)^2C^2(V_A^*)^2$$

$I \uparrow K^2 2eF\Delta f$

$$\therefore \quad \Delta f \leq \Delta f_2 = \frac{3(eMFK)^2}{(\pi C V_A^*)^2}$$

$K = 12 \quad C = 5pF \quad M = 100 \quad F = 6 \quad Si\text{-}APD$

Si-FET Amp $\quad (\Delta f)_1 = 20\,Hz \quad (\Delta f)_2 = 1\,GHz$

Si-BJT $\quad (\Delta f)_1 = 750\,kHz \quad (\Delta f_2) = 4\,GHz$

3 Low Resistance $\Delta f \ll \frac{1}{RC} \cdot \frac{1}{2\pi}$

Over what range of R does thermal noise dominate
(If $\Delta f \ll \frac{1}{2\pi RC}$)

$$\frac{1}{R^x} > \frac{4kT}{(V_A^*)^2} \times \frac{1}{R} \qquad \text{so} \quad R < \frac{V_A^*}{4kT}$$

$$4kT\left(\frac{1}{R}\right) < (I_A^*)^2 \qquad \text{so} \quad R > \frac{4kT}{(I_A^*)^2}$$

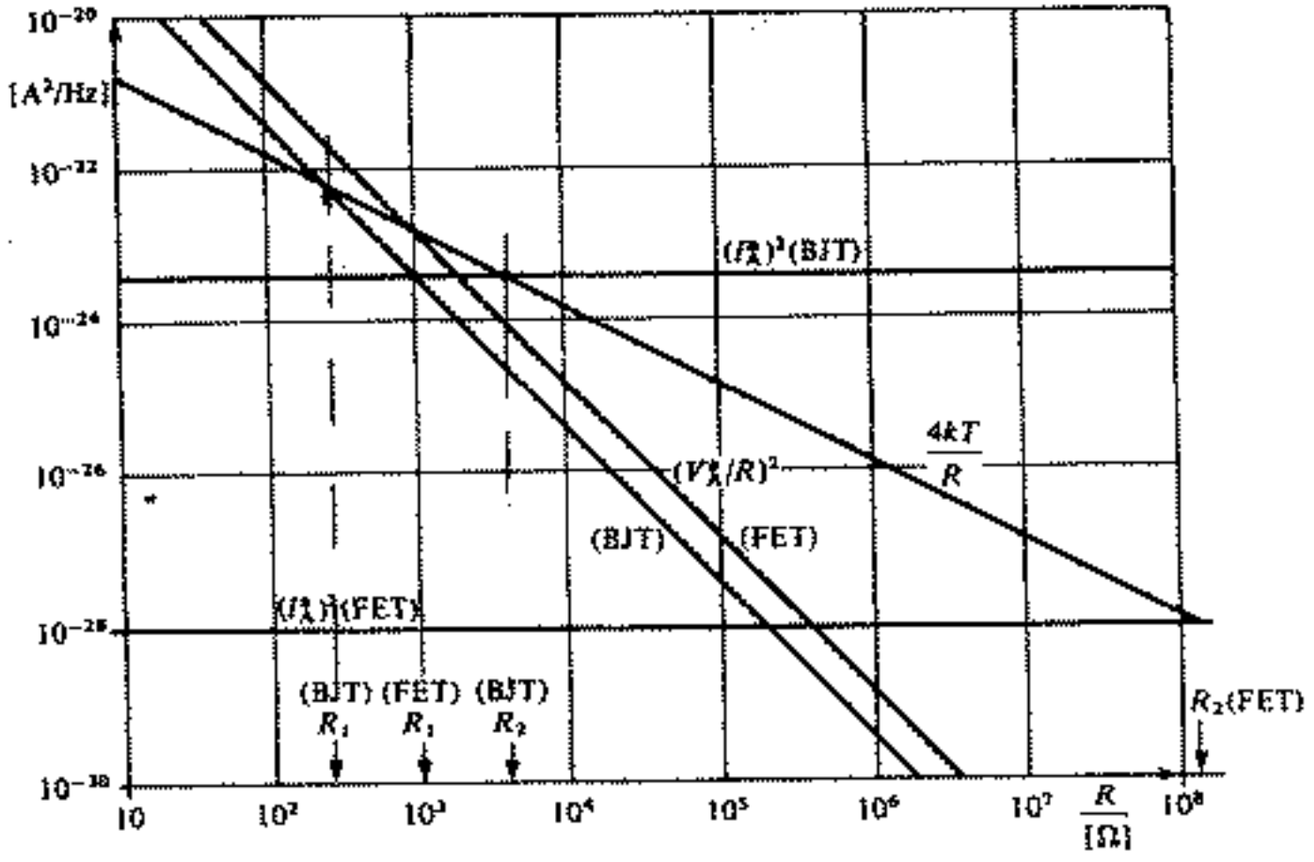


Fig. 14.9 Variation of amplifier and thermal noise sources with amplifier input resistance.

Between R_1 & R_2 thermal noise > amp noise.

Limit When Resistance is Low and Band-width Limited by RC $\left(\Delta f = \frac{1}{2\pi RC}\right)$ or $\left(\left(\frac{1}{R}\right)^2 = (2\pi)^2(\Delta f\, C)^2\right)$

$$K = \frac{I}{\sqrt{\Delta f\left[\frac{(V_A^*)^2}{M^2}\,\frac{16\pi^2(\Delta f)^2C^2}{3} + 2eIF + \frac{4kT}{M^2R} + \frac{(I_A^*)^2}{M^2}\right]}}$$

$\frac{1}{R} = (2\pi\,\Delta f\, C)$

Shot Noise Dominates Thermal For

$$2eIM^2F > \frac{4kT}{R} = 8\pi kTC\,\Delta f \qquad \left(R \to \tfrac{1}{2\pi C\Delta f}\right)$$

If this applies, we may, as before, substitute the minimum quantum noise limited current for I, namely

$$I = 2e\,\Delta f\,FK^2$$

so that

$$(2eMFK)^2\,\Delta f > 8\pi kTC\,\Delta f$$

$$C < \frac{(eMFK)^2}{2\pi kT}$$

$M = 100 \quad F = 6, \; K = 12 \quad C_0 = 50\,pF$

And over the band-width range

$$\Delta f > \frac{(I_A^*)^2}{(2eMFK)^2} \qquad \Delta f < \frac{3(2eMFK)^2}{16\pi^2(V_A^*)^2}\,\frac{1}{C^2}$$