Lecture 24: Equivalent Input-Referred Noise

- Announcements:
- HW#7 online next week and due Friday morning, May 8
- Project slide #3 due Friday, May 1
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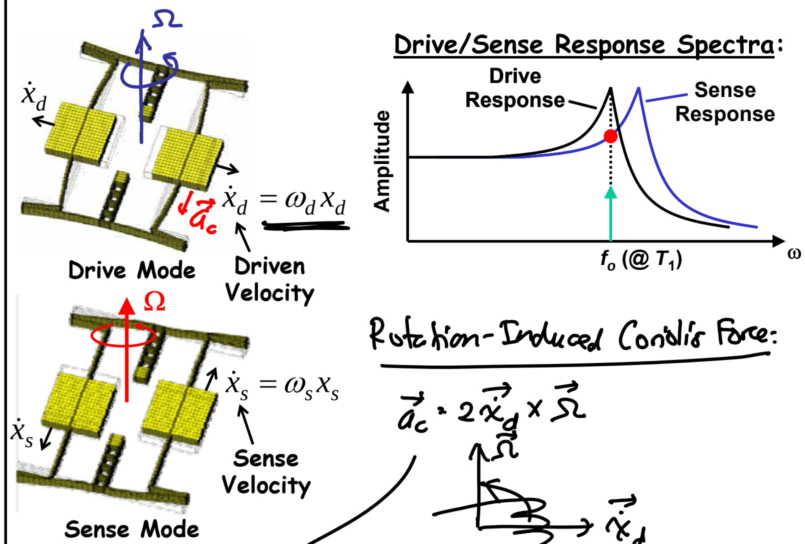
- Reading: Senturia Chpt. 16
- Lecture Topics:
  - Minimum Detectable Signal
  - Noise
    - Circuit Noise Calculations
    - Noise Sources
    - Equivalent Input-Referred Noise
  - Gyro MDS
    - Equivalent Noise Circuit
    - Example ARW Determination
- ------------------------------------
- Last Time:
- Noise & noise calculations, ending up in Module 17, slide 29
- Now, continue with input referred noise

over

Gyroscope Drive-to-Sense Xfer Fcn



Rotation-Induced Coriolis Force:

$\vec{a}_c = 2\dot{\vec{x}}_d \times \vec{\Omega}$

$= 2\omega_d \vec{x}_d \times \vec{\Omega}$ → acts in the sense mode direction

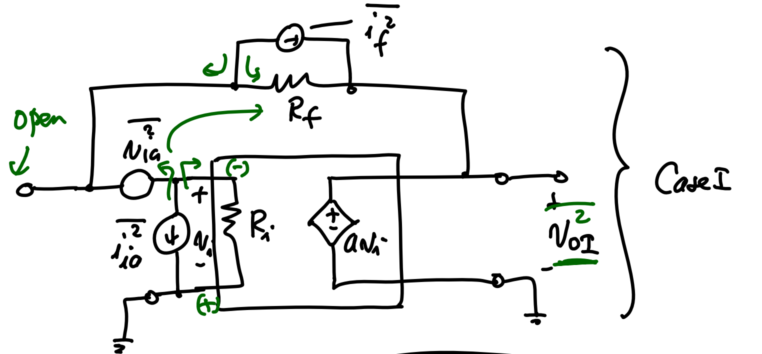
$a_s = a_c = 2\omega_d x_d \Omega \sin 90°$

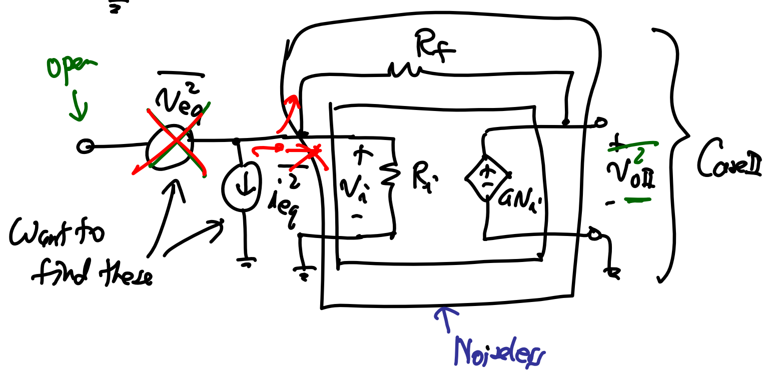
$$a_s = 2\omega_d x_d \Omega$$

Ω: rotation rate; ω_d: drive radian frequency; x_d: drive displacement amplitude

$F_c = m a_s = m a_c$

Example. TransR Amplifier Input-Referred Noise





Input-referred Current Noise:

Open inputs; equate output voltage noise for Case I & II:

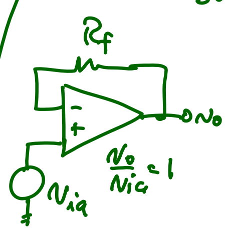
Case I:

$\overline{i_{ia}^2}$: $v_{oI1} = i_{ia}R_f \rightarrow \overline{v_{oI1}^2} = \overline{i_{io}^2}R_f^2$ → power @ output generated by noise sources

$\overline{i_f^2}$: $v_{oI2} = i_f R_f \rightarrow \overline{v_{oI2}^2} = \overline{i_f^2}R_f^2$

$\overline{v_{ia}^2}$: $v_{oI3} = v_{ia} \rightarrow \overline{v_{oI3}^2} = \overline{v_{io}^2}$

$\therefore \overline{v_{oI}^2} = \overline{i_{ia}^2}R_f^2 + \overline{i_f^2}R_f^2 + \overline{v_{ia}^2}$

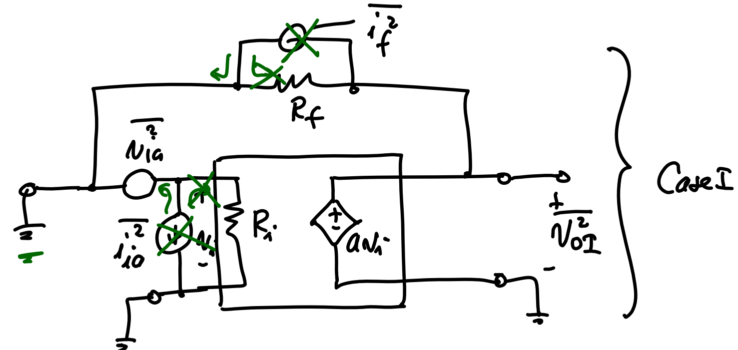


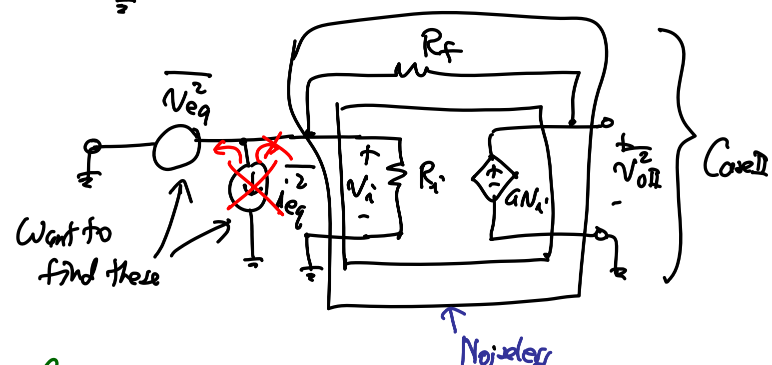
Case II: $\overline{v_{oII}^2} = \overline{i_{eq}^2}R_f^2$

Now, set $\overline{v_{oI}^2} = \overline{v_{oII}^2}$: $\boxed{\overline{i_{eq}^2} = \overline{i_{ia}^2} + \overline{i_f^2} + \frac{\overline{v_{ia}^2}}{R_f^2}}$

Now, get the input-referred voltage-noise:

Short inputs; equate output voltage noise.





Case I: $v_{oI} = av_{ia} \rightarrow \overline{v_{oI}^2} = a^2\overline{v_{ia}^2}$

Case II: $v_{oII} = av_{eq} \rightarrow \overline{v_{oII}^2} = a^2\overline{v_{eq}^2}$

$\overline{v_{oI}^2} = \overline{v_{oII}^2}$: $\boxed{\overline{v_{eq}^2} = \overline{v_{ia}^2}}$