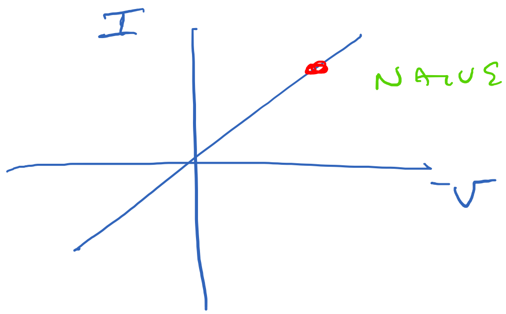
PHASE DETECTOR

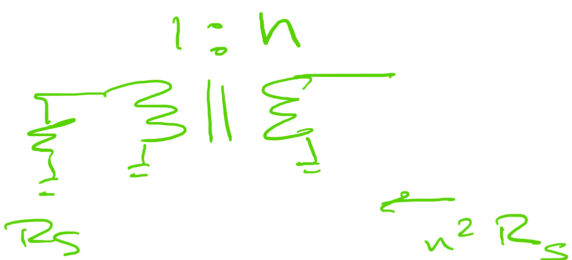
e.g. RESISTANCE THERMOMETRY w/ LOW-LEVEL EXCITATION



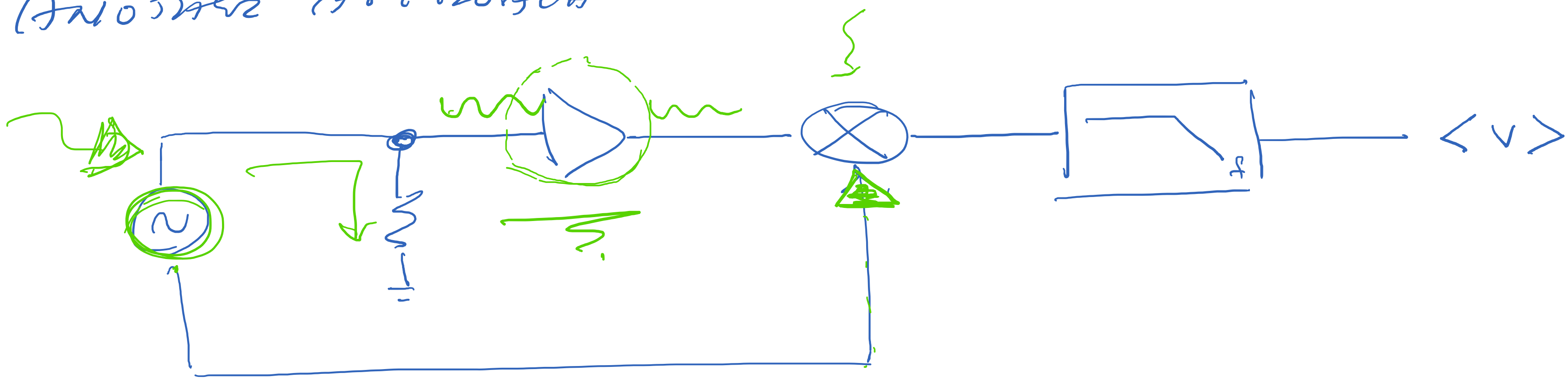
NAIVE APPROACH: BIAS w/ CURRENT, MEASURE VOLTAGE

PROBLEMS:

1. 1/f NOISE OF AMP
2. LOW-FREQUENCY DRIFT
3. $R_S \neq R_{N,\,opt.}$

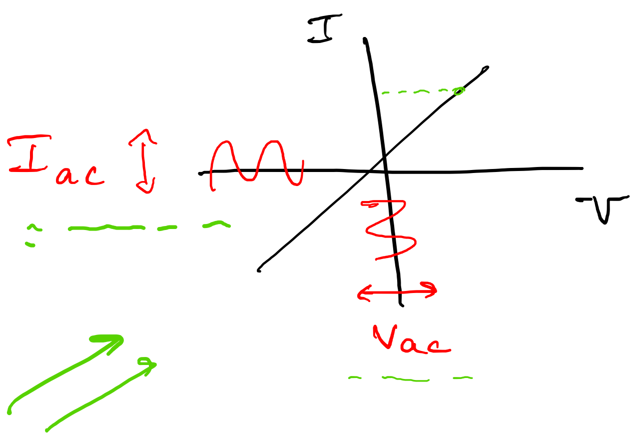


ANOTHER APPROACH



MODULATE EXCITATION @ NONZERO FREQUENCY f_0

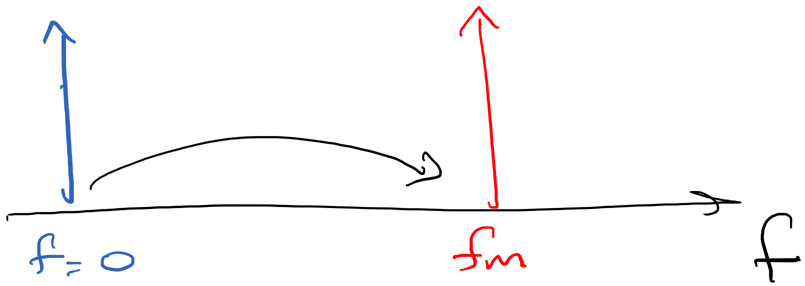
→ DETECT IN NARROW BAND AROUND f_0



→ $V_{AC} = R_{DYN} \cdot I_{AC}$

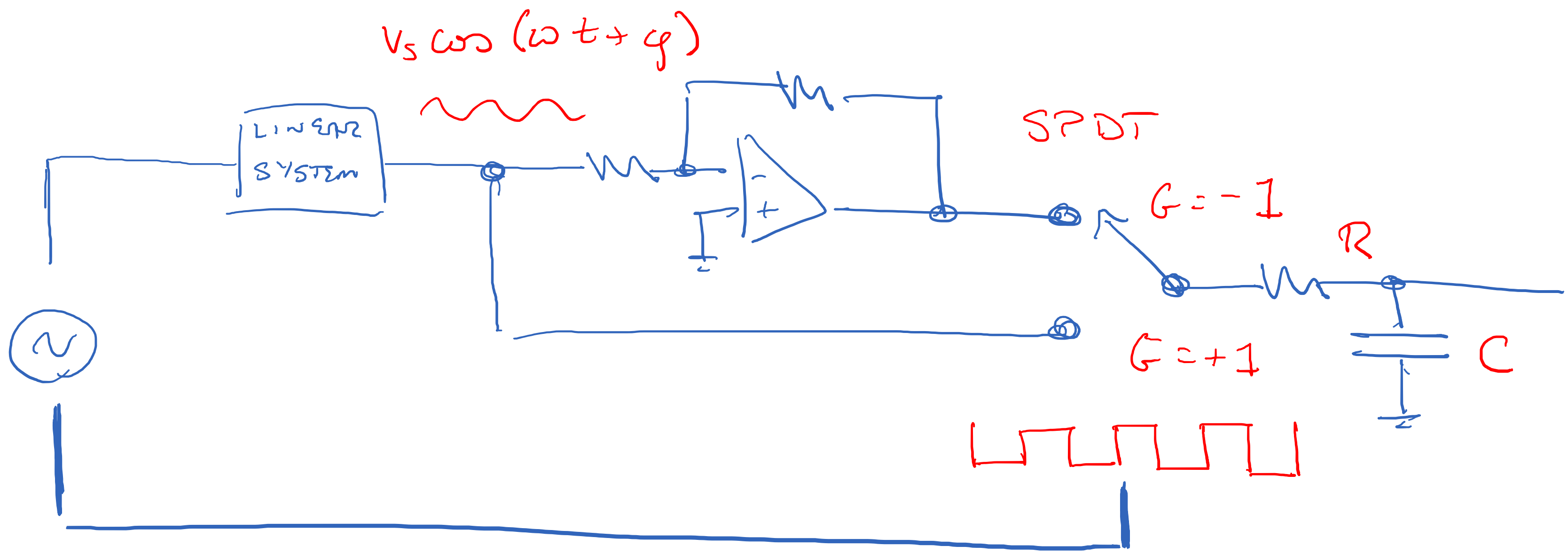
$V(t) = R_{DYN} \cdot I_0 \cos \omega_m t$

WHAT DOES THIS ACCOMPLISH?

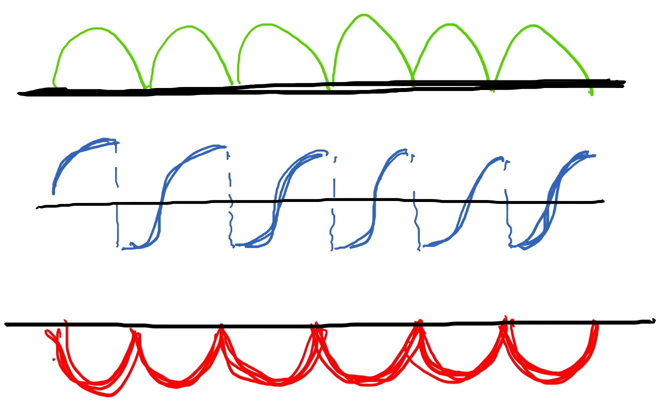


→ ESCAPE 1/f NOISE

ALSO, CAN NOW TRANSFORM SOURCE IMPEDANCE TO OPTIMALLY NOISE MATCH.



POSSIBILITIES:



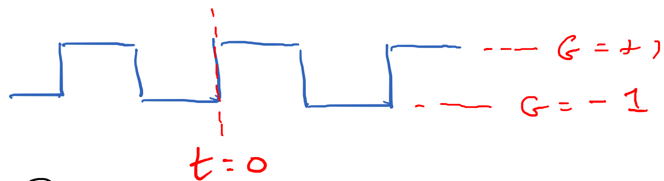
IN PHASE — $\langle v_o \rangle > 0$

90° SHIFT — $\langle v_o \rangle = 0$

180° SHIFT — $\langle v_o \rangle < 0$

Assume $RC \gg 2\pi/\omega_m$ → Just look @ DC part of output

REF.



Look @ $\langle V_s \cos(\omega t + \varphi) \rangle \Big|_0^{\pi/\omega} - \langle V_s \cos(\omega t + \varphi) \rangle \Big|_{\pi/\omega}^{2\pi/\omega}$

$$= \frac{\omega}{2\pi} V_s \left\{ \int_0^{\pi/\omega} \cos(\omega t + \varphi)\, dt - \int_{\pi/\omega}^{2\pi/\omega} \cos(\omega t + \varphi)\, dt \right\}$$

$$= \frac{V_s}{2\pi} \left\{ \sin(\omega t + \varphi) \Big|_0^{\pi/\omega} - \sin(\omega t + \varphi) \Big|_{\pi/\omega}^{2\pi/\omega} \right\}$$

$$= \frac{V_s}{2\pi} \left\{ 2 \sin(\pi + \varphi) - \sin\varphi - \sin(\varphi + 2\pi) \right\}$$

$$\boxed{V_{DC} = -\frac{2 V_s}{\pi} \sin\varphi}$$

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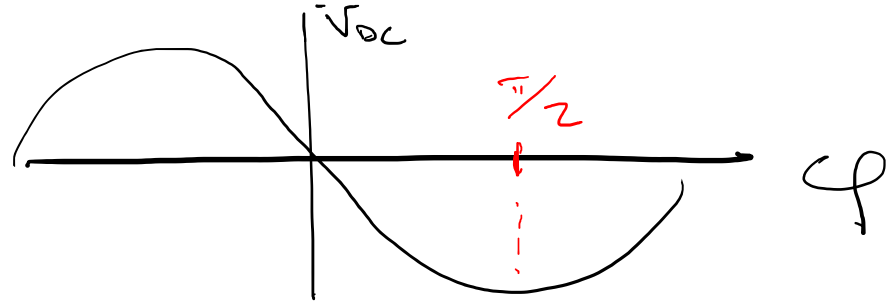

FOR $\omega_s \neq \omega_m$

$$v_{out} = -\frac{2 v_s}{\pi} \sin \Delta\omega t$$