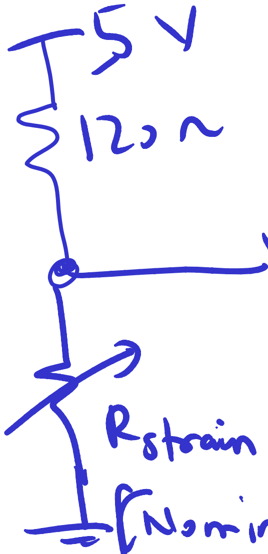
EE100Su08 Lecture #13 (July 25th 2008)

- Outline
  - MultiSim licenses: postponed to Monday, July 28th 2008
    - Apparently our license number is not working!
    - Thanks for coming to lecture today!
  - HW #2: regrade deadline: Monday, 07/28, 5:00 pm PST.
  - Midterm #1 regrades: I will finish em by office hours today.
  - QUESTIONS?
  - Strain Gauge and Project: Lab Lecture
    - WARNING: BE REALLY CAREFUL AROUND THE STRAIN GAUGE SINCE THE APPARATUS “STICKS OUT” OF THE TABLE!
  - Frequency Response and Bode plots ← Monday
  - Nonlinear circuits
- Reading
  - Chapter 9 from your book (skip 9.10, 9.11 (duh)), Appendix E* (skip second-order resonance bode plots)
  - Chapter 1 from your reader (skip second-order resonance bode plots)

Strain Gauge



$$V_S = \frac{5 \cdot R_{strain}}{120 + R_{strain}}$$

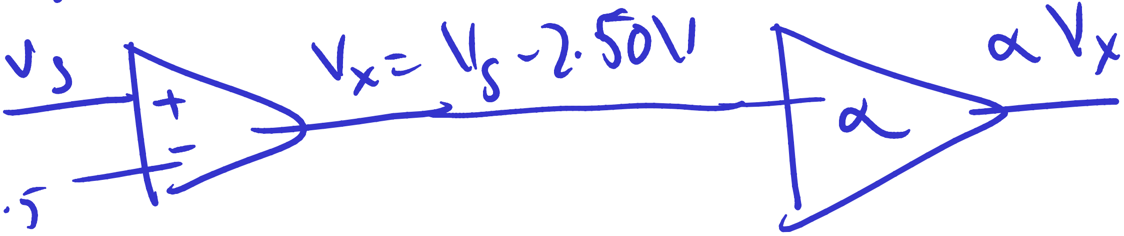
max. $(R_{strain} = 120.5)$ → 2.5052 V

nominal $(R_{strain} = 120\,\Omega)$ → 2.5 V

minimum $(R_{strain} = 119.5\,\Omega)$ → 2.4948 V

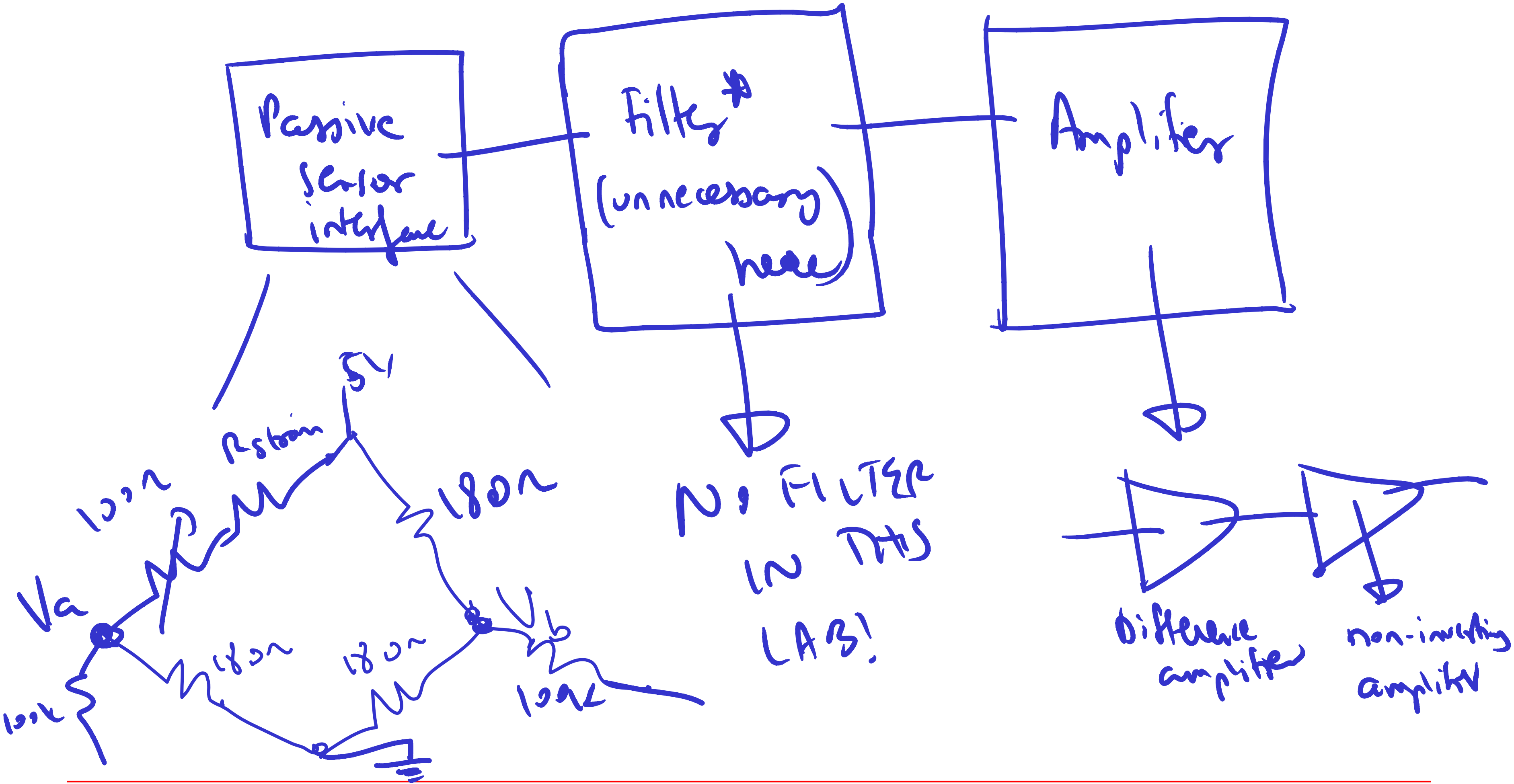
[Nominal = 120 Ω,
max: 120.5 Ω
min: 119.5 Ω]

Voltage divider does not give a good dynamic range, but one possible interface:

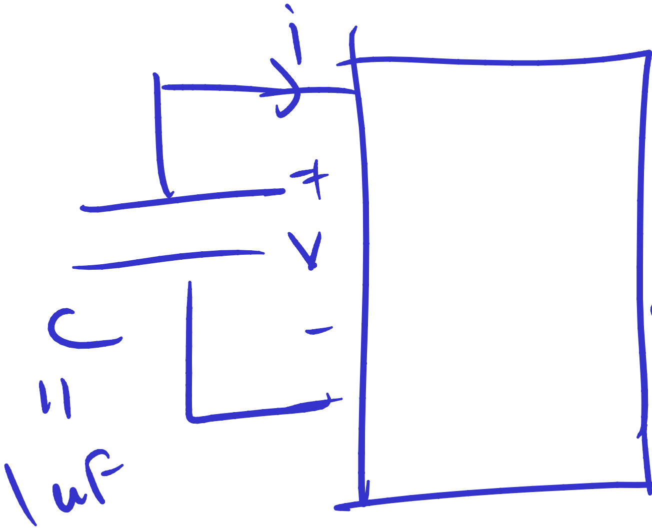


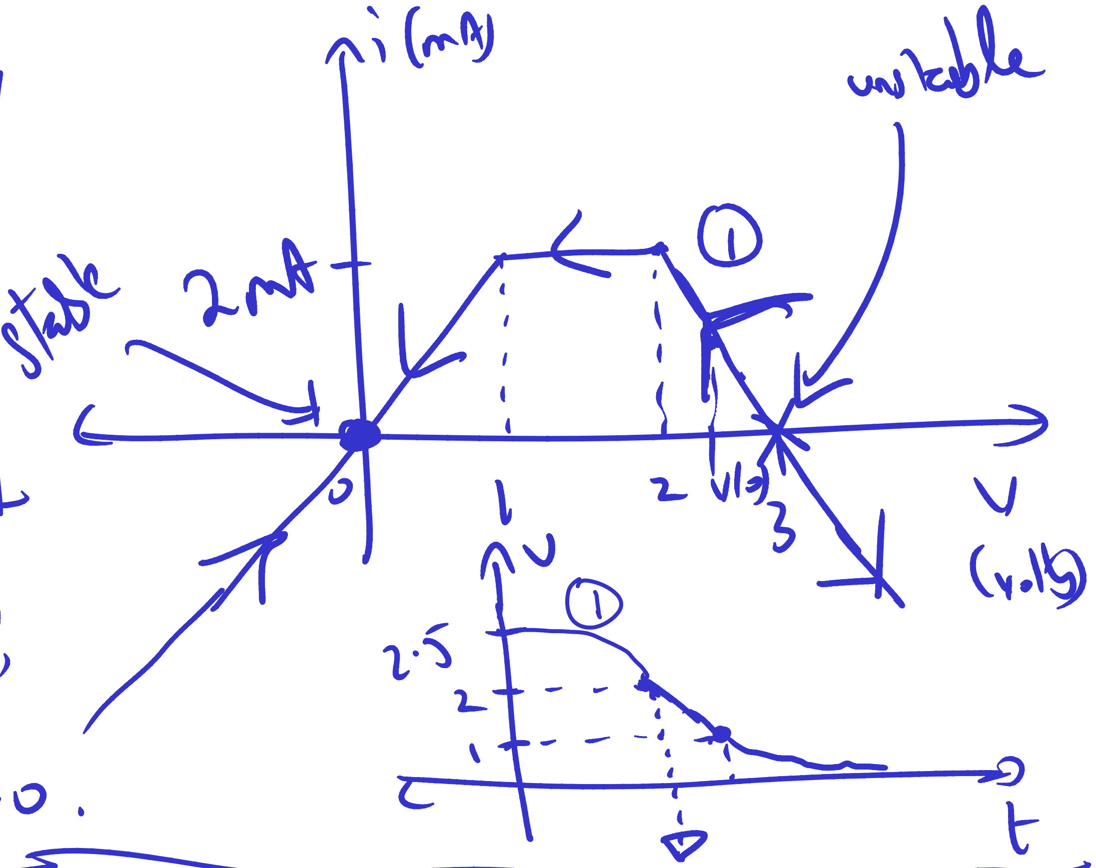
Strain Gauge

Previous interface is not too "nice":



Nonlinear circuit example





Suppose $v(0) = 2.5V$,

Sketch $v(t)$ $t \geq 0$.

(1) eq. points: $v' = 0 \Rightarrow \boxed{i = 0}$

$$\left[i = -C\frac{dv}{dt} \right]$$

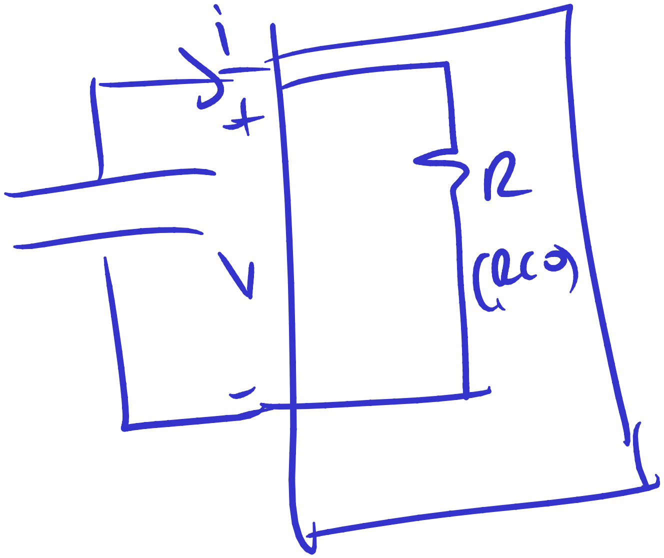
$\Downarrow$

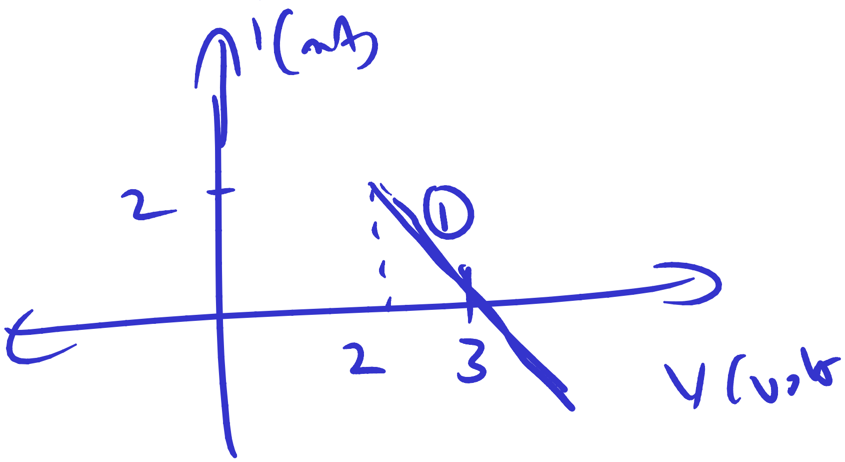
x-axis intersection

(2) Dynamic route

$i > 0$	$i < 0$
$v' < 0$	$v' > 0$

Region ①





$$R_{①} = \frac{1}{\Delta} = \frac{1}{\frac{-2\,mA}{1}} = \underline{\underline{-500\,\Omega}}$$

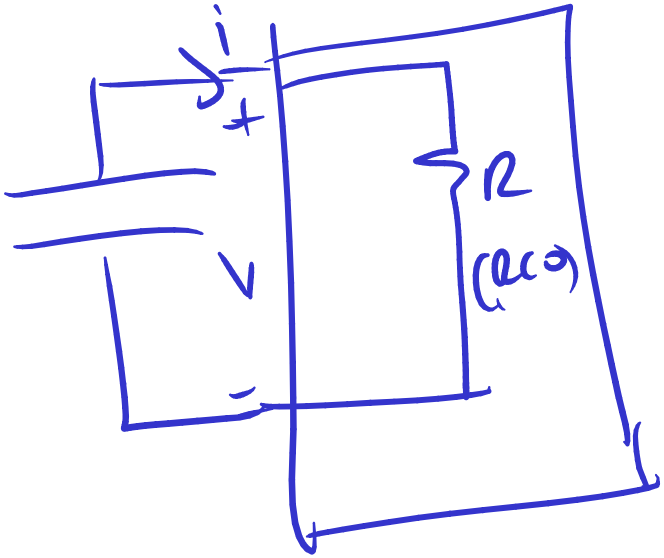
$$v_{①}(t) = A + Be^{-t/\tau}$$

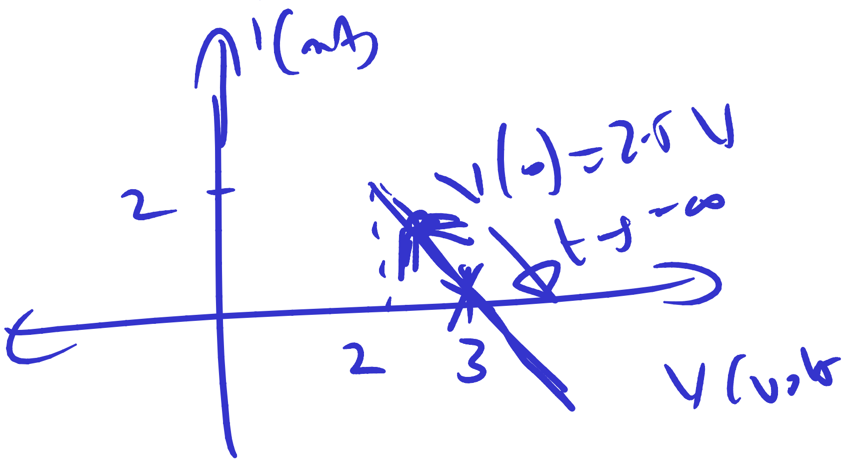
$$= A + Be^{\frac{-t}{R_{①}C}} = A + Be^{\frac{-t}{-500 \cdot 1\mu F}}$$

$$\left[\underline{\text{Usually}}:\ v_{①}(t) = v_f + (v_i - v_f)e^{-t/\tau}\right]$$

$$v_{①}(t) = A + Be^{\frac{t}{0.5\,ms}} \quad //$$

Region ①





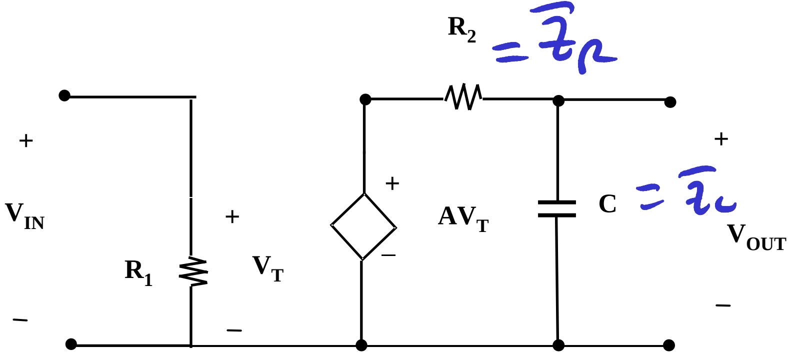
$$v_{\textcircled{1}}(t) = A + Be^{\frac{t}{0.5\,ns}}. \quad v_{\textcircled{1}}(0) = 2.5$$

$$\Rightarrow A + B = 2.5 \Rightarrow B = -0.5$$

$$v_{\textcircled{1}}(t \to -\infty) = A = 3$$

$$\boxed{v_{\textcircled{1}}(t) = 3 - 0.5e^{t/0.5\,ns} \text{ volts}}$$

Example Circuit



$$\overline{V_{out}} = \frac{\overline{Z_c}}{\overline{Z_R}+\overline{Z_c}} \cdot A\overline{V_T}$$

$$TransferFunction = \frac{\mathbf{V}_{OUT}}{\mathbf{V}_{IN}}$$

$$\frac{\mathbf{V}_{OUT}}{\mathbf{V}_{IN}} = \frac{AZ_c}{Z_R + Z_c}$$

A = 100

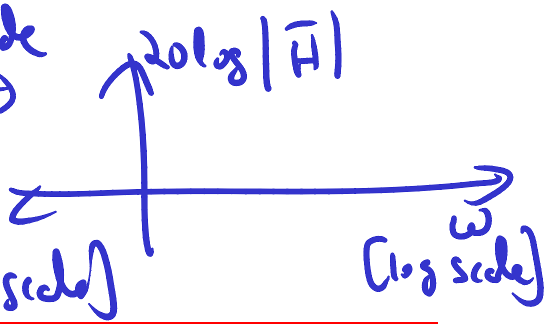
R_1 = 100,000 Ohms

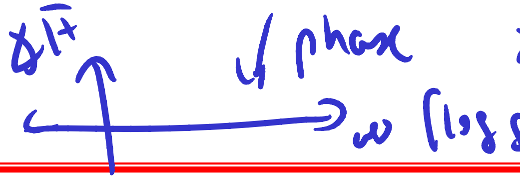
R_2 = 1000 Ohms

C = 10 uF

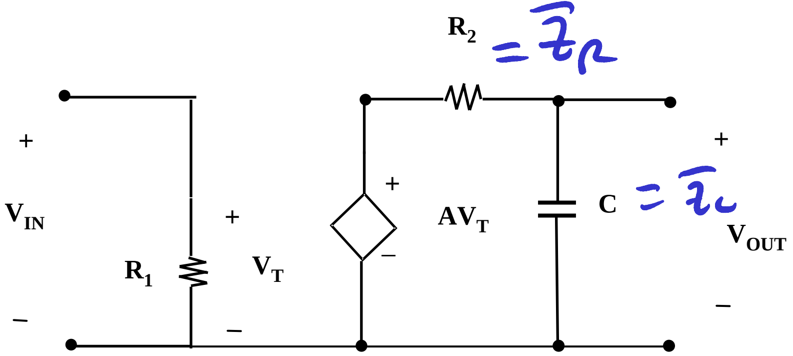
$$\overline{H} = \frac{\mathbf{V}_{OUT}}{\mathbf{V}_{IN}} = \frac{A(1/\,jwC)}{(R_2 + 1/\,j\omega C)} = \frac{A}{(1 + j\omega R_2 C)}$$

magnitude →





Example Circuit



$$\overline{V_{out}} = \frac{\overline{Z_C}}{\overline{Z_R}+\overline{Z_C}} \cdot A\overline{V_T}$$

$$\overline{H} = \frac{A}{(1+j\omega R_2 C)}$$

$$20\log|\overline{H}| = 20\log\frac{|A|}{|1+j\omega R_2 C|} = 20\log\left(\frac{A}{\sqrt{1+(\omega R_2 C)^2}}\right)$$

$$20\log|\overline{H}| = 20\log A - 20\log\sqrt{1+(\omega R_2 C)^2}$$

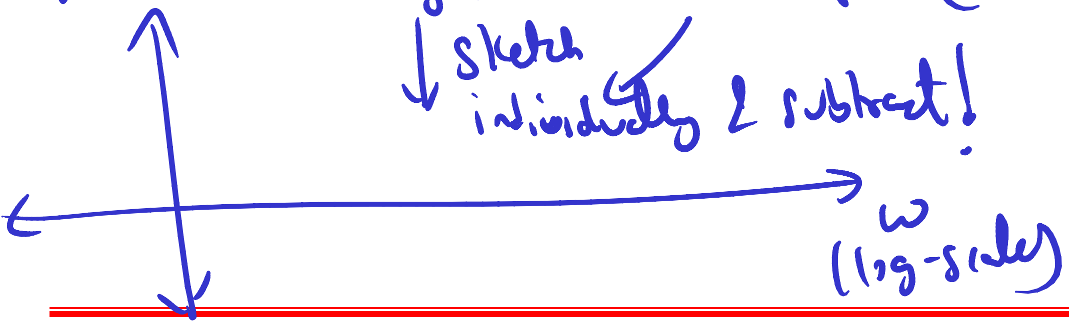
sketch individually & subtract!

A = 100

R_1 = 100,000 Ohms

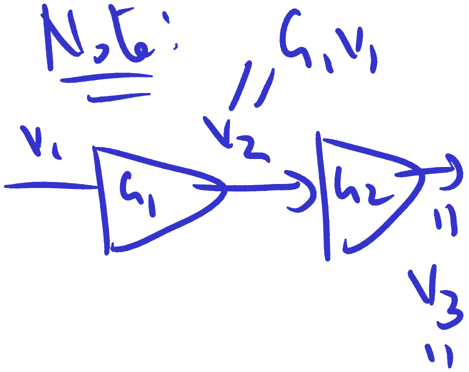
R_2 = 1000 Ohms

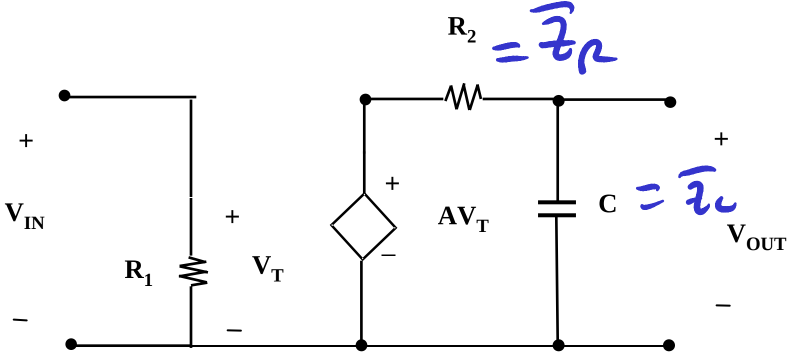
C = 10 uF



Example Circuit

Note:





$$\bar{V}_{OUT} = \frac{\bar{Z}_C}{\bar{Z}_R + \bar{Z}_C} \cdot A\bar{V}_T$$

$$\bar{H} = \frac{A}{(1 + j\omega R_2 C)}$$

$$G_2V_2 = G_2G_1V_1 \Rightarrow \boxed{\frac{V_3}{V_1} = G_2G_1}$$

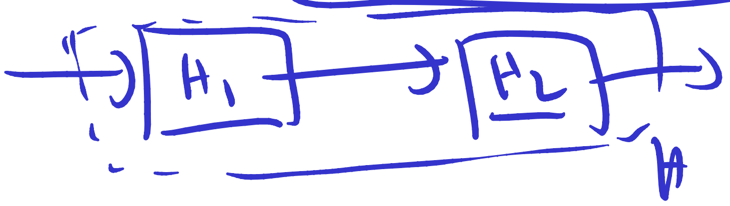
A = 100

R_1 = 100,000 Ohms

R_2 = 1000 Ohms

C = 10 uF

Transfer fcns:



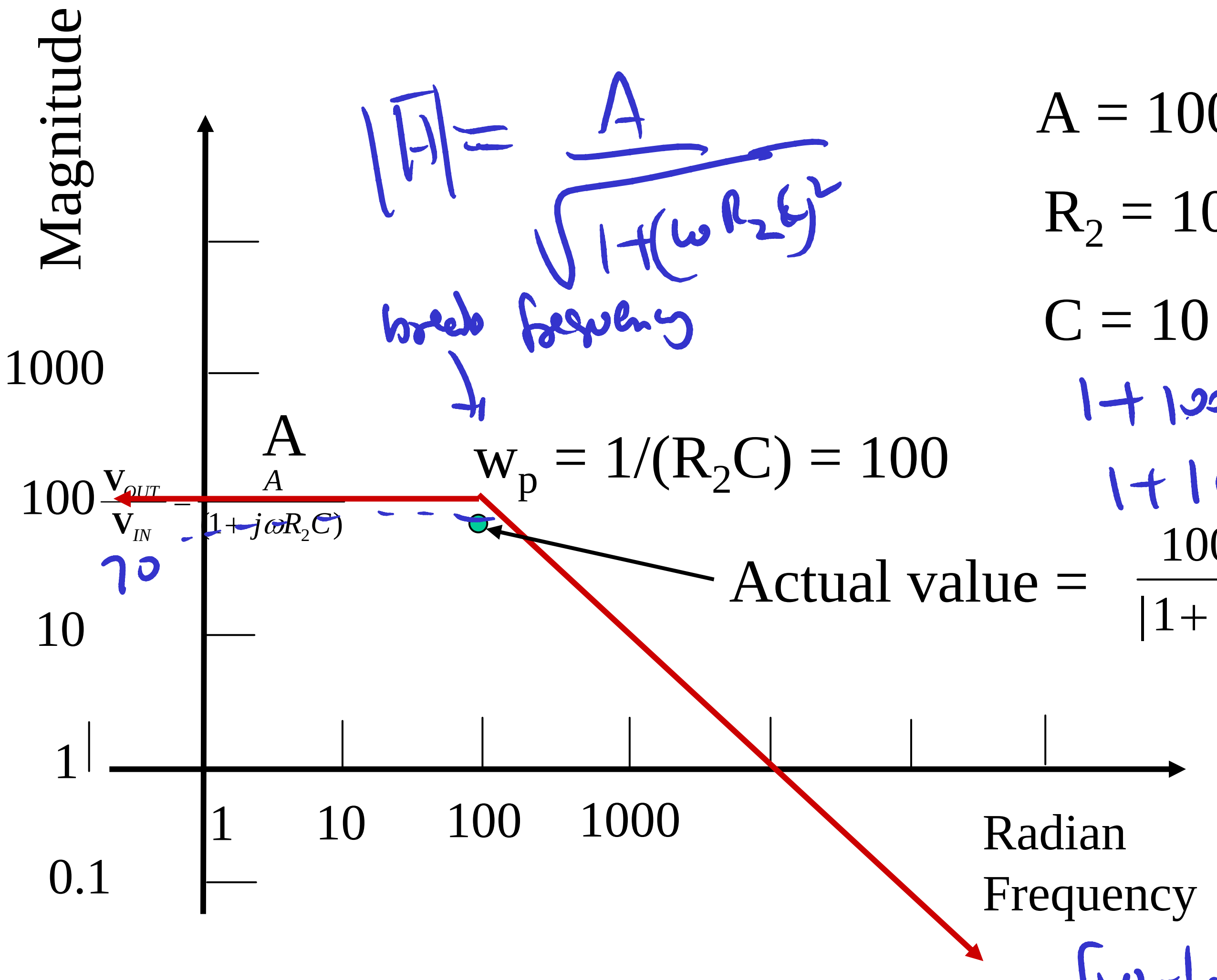
$$H = H_1H_2 \Rightarrow 20\log_{10}|H|$$

$$= 20\log_{10}|H_1H_2| = 20\log_{10}|H_1| + 20\log_{10}|H_2|$$

Break Point Values

- When dealing with resonant circuits it is convenient to refer to the frequency difference between points at which the power from the circuit is half that at the peak of resonance.
- Such frequencies are known as “half-power frequencies”, and the power output there referred to the peak power (at the resonant frequency) is
- $10\log_{10}(P_{half\text{-}power}/P_{resonance}) = 10\log_{10}(1/2) = -3$ dB.

Example: Circuit in Slide #2 Magnitude



$$\frac{V_{OUT}}{V_{IN}} = \frac{A}{(1+j\omega R_2 C)}$$

$w_p = 1/(R_2C) = 100$

$$\text{Actual value} = \frac{100}{|1+j|} = \frac{100}{\sqrt{2}}$$

$$|H| = \frac{A}{\sqrt{1+(\omega R_2 C)^2}}$$

A = 100

R_2 = 1000 Ohms

C = 10 uF

1+100.1000.10uF

1+1 ✓

[ω - log scale]

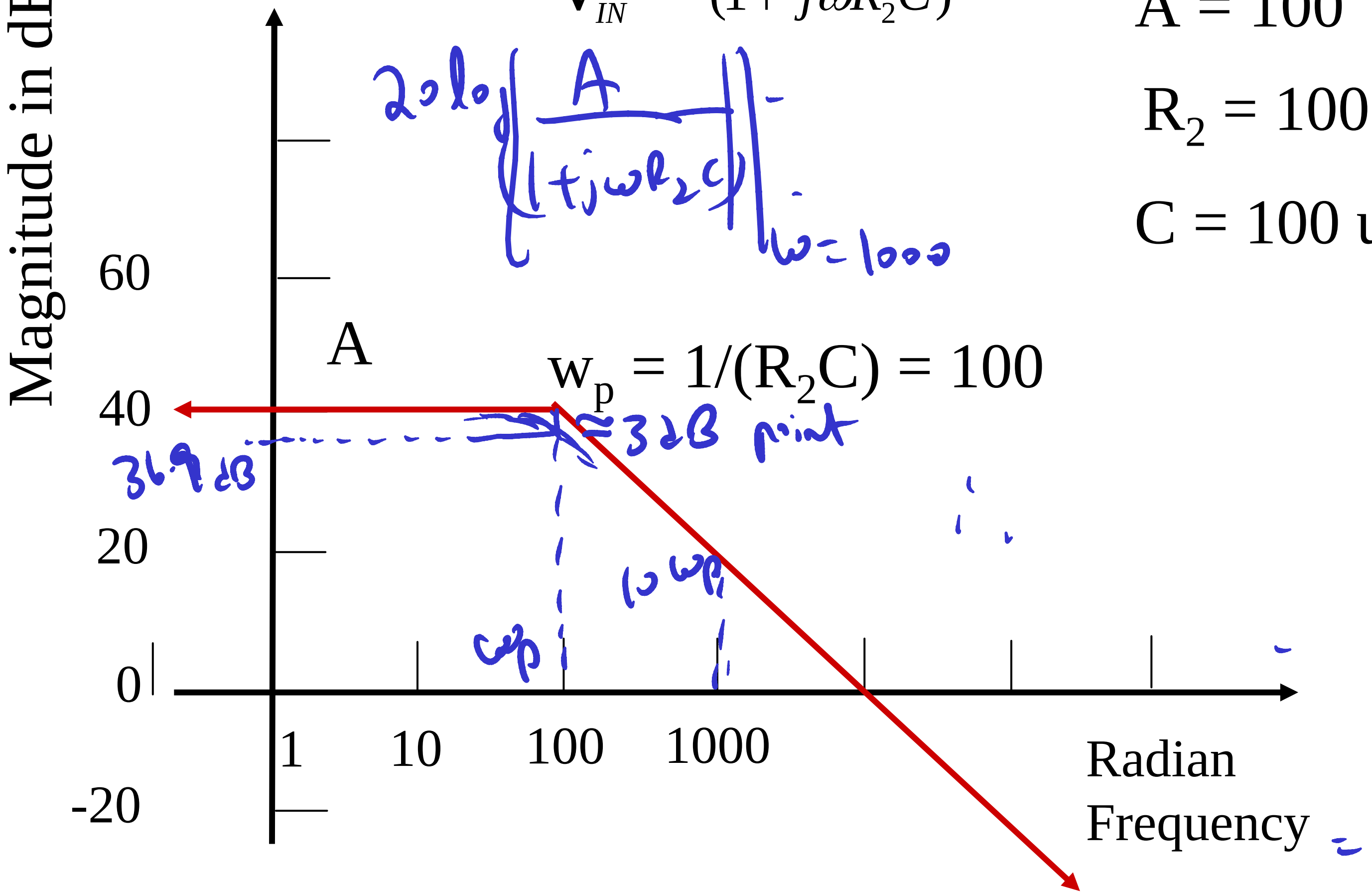
Bode Plot: Label as dB

$$\frac{\mathbf{V}_{OUT}}{\mathbf{V}_{IN}} = \frac{A}{(1 + j\omega R_2 C)}$$

A = 100

R_2 = 1000 Ohms

C = 100 uF



$w_p = 1/(R_2C) = 100$

Note: Magnitude in dB = 20 $\log_{10}(V_{OUT}/V_{IN})$