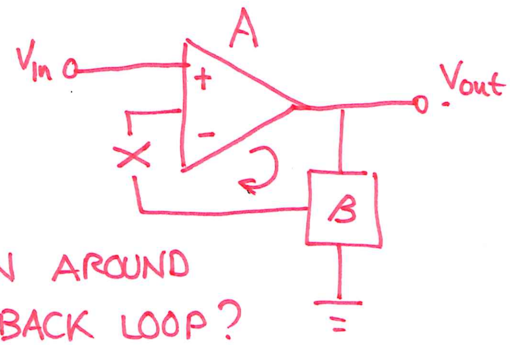
Loop Gain: $A\beta$ QUANTITY



GAIN AROUND FEEDBACK LOOP?

$A\beta$ "LOOP GAIN" ← CAN GET STABILITY PROPERTIES JUST FROM $A\beta$

A "<u>OPEN</u> LOOP GAIN" (NO FEEDBACK)

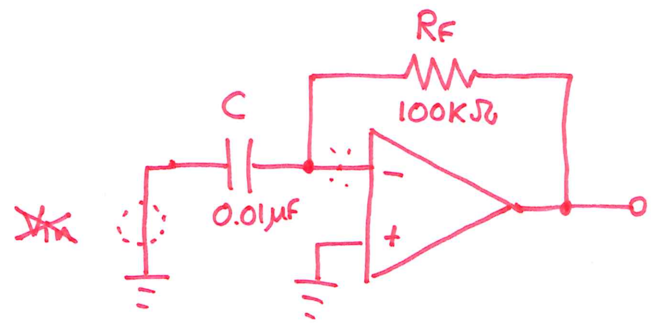
$\dfrac{A}{1+A\beta}$ "CLOSED LOOP GAIN" (WITH FEEDBACK WORKING)

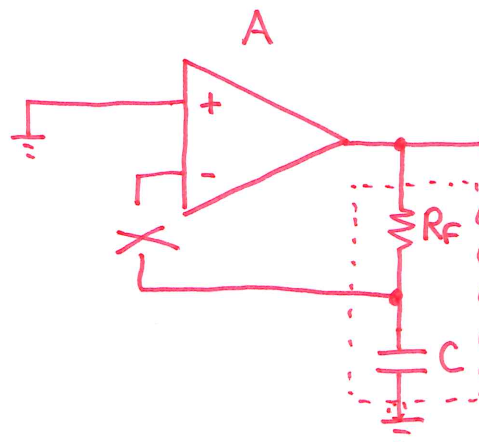
Finding Loop Gain; Differentiator

1

Set all independent sources equal to zero

STABILITY IS A PROPERTY OF THE SYSTEM (NOT Vin, Vout)





S.T.C. LOWPASS FILTER

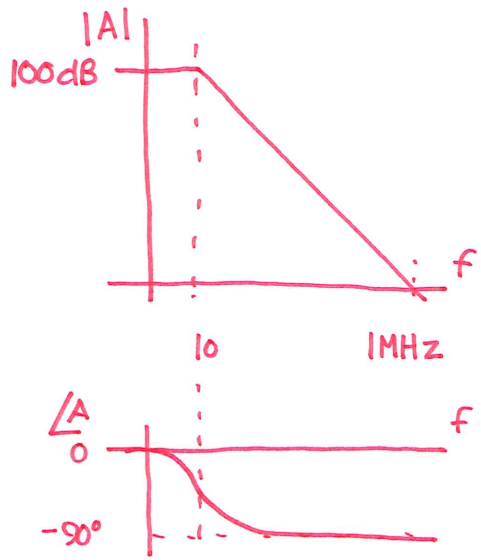
2

Break feedback loop (don't change loading)

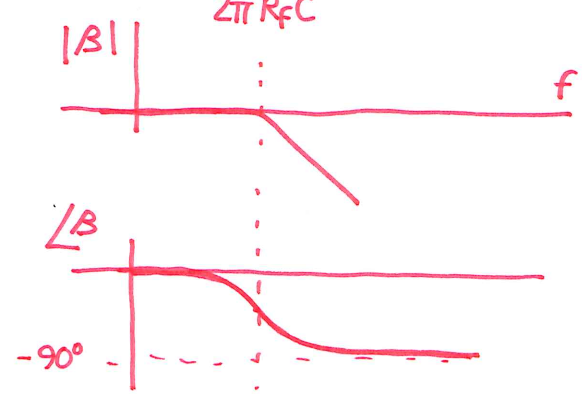
2A

Redraw in A, β format for clarity (optional)

LM741



$$\frac{1}{2\pi R_F C} = 160\text{ Hz}$$



3

Find

$|A|, |\beta| \quad \angle A, \angle\beta$

Stability Analysis Procedure

1

Plot Loop Gain

$|A\beta| \angle A\beta$

$|A\beta| = \underbrace{|A||\beta|}_{\text{ADD dB}}$

2

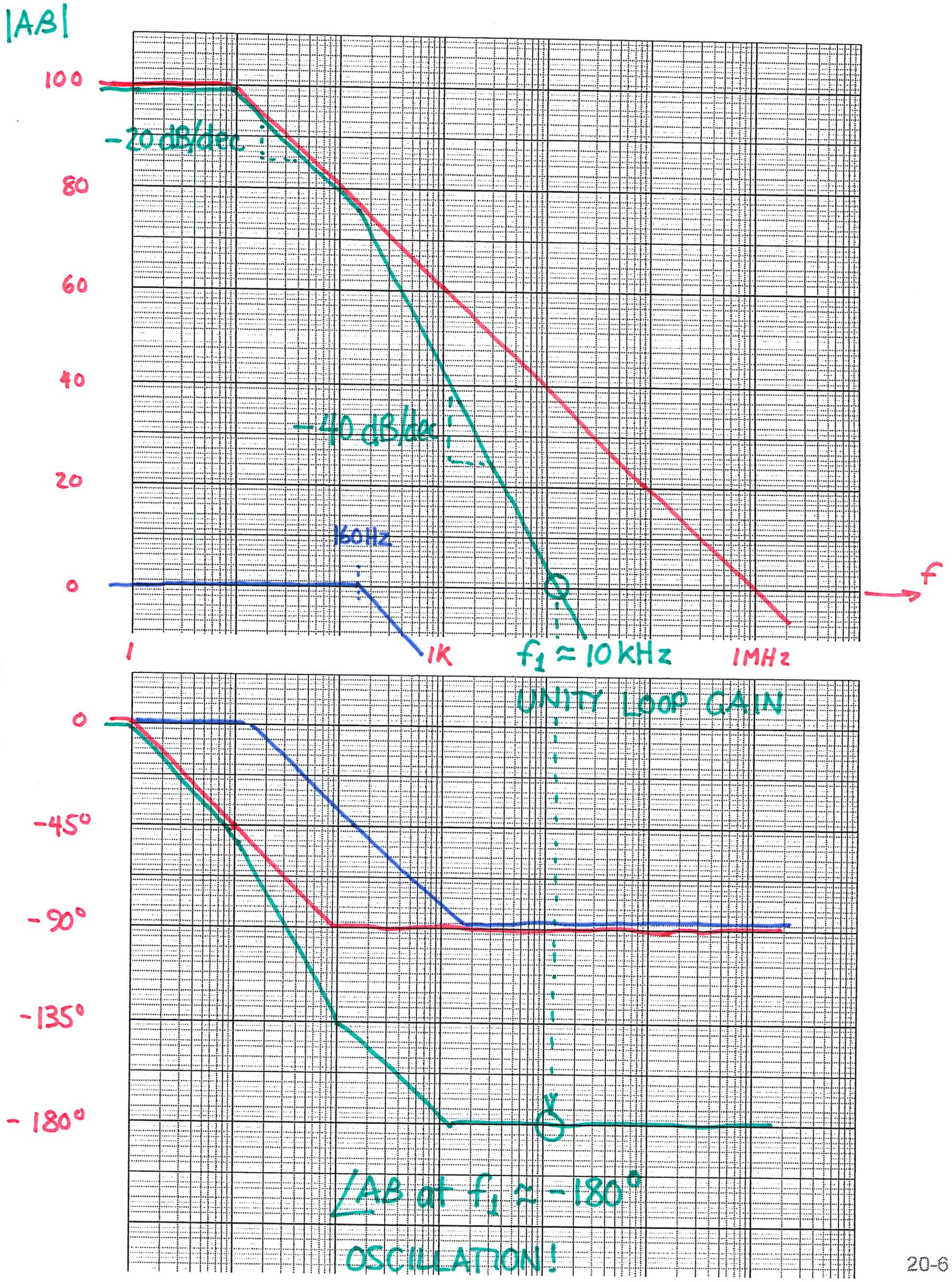
Find f_1

Frequency at which $|A\beta| = 1$

$\angle A\beta = \underbrace{\angle A + \angle \beta}_{\text{ADD PHASE}}$

3

Check $\angle A\beta$ at f_1 compared to -180°



ECE3204 Lecture 21

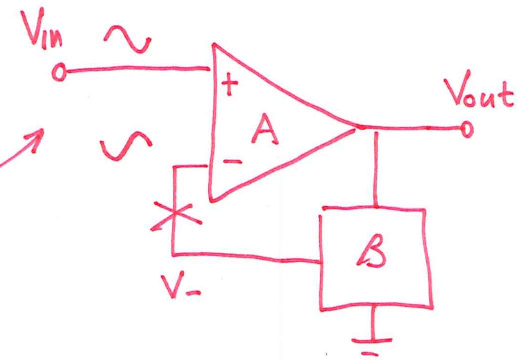
Intuitive view of stability
Practical Differentiator
Stability analysis (Ch. 10)

Handouts:
Practical Differentiator

Intuitive view of stability

CONDITION: $|A\beta| = 1$
$\angle A\beta = -180$

PUTS POLES OF CLOSED LOOP $\frac{V_{out}}{V_{in}}$ ON $j\omega$ AXIS
→ CONTINUOUS SINUSOID

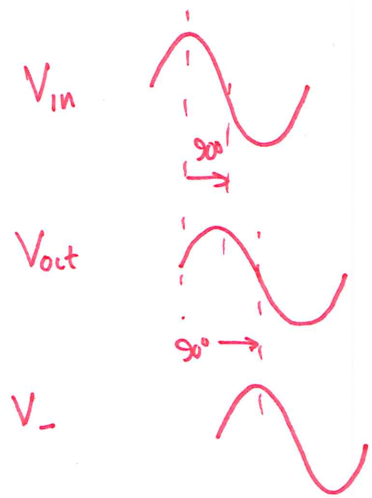


A: 90° ϕ LAG

β: 90° ϕ LAG

180 PHASE INVERSION AT THIS FREQUENCY

TURNS − FEEDBACK INTO + FEEDBACK



Practical Differentiator (Lab 6)

The circuit of Figure 6.1 can be made more stable by inserting a resistor in series with the capacitor, as shown in Figure 6.5.

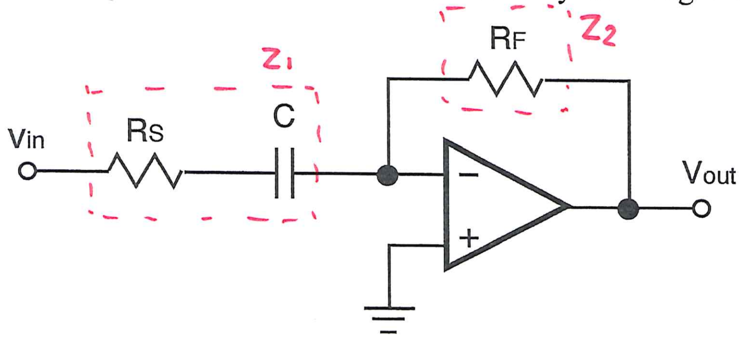
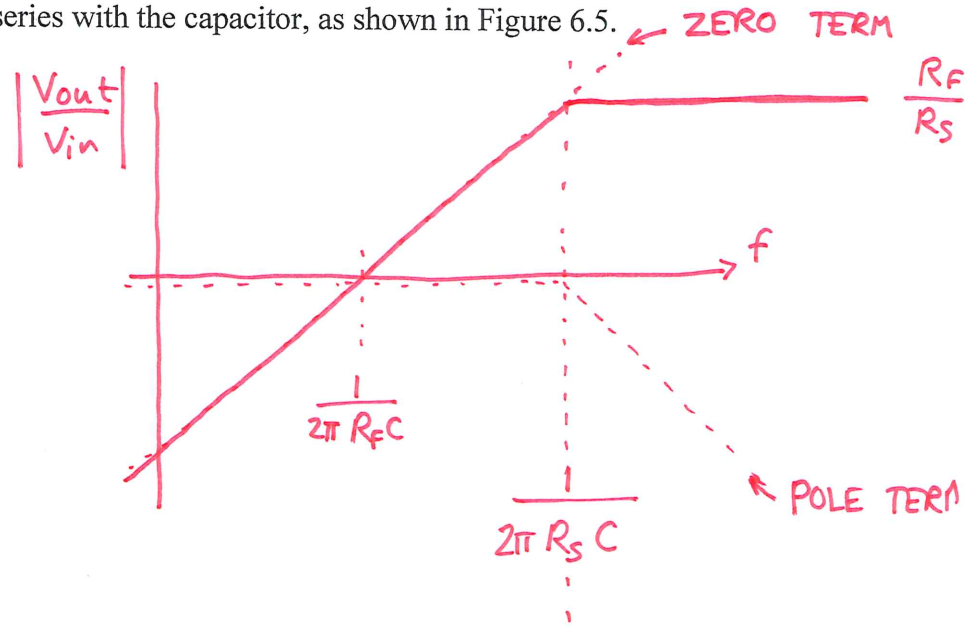


Figure 6.5



TRANSFER FUNCTION (ASSUME OP-AMP IDEAL)

$$\frac{V_{out}}{V_{in}} = \frac{-Z_2}{Z_1} = \frac{-R_F}{R_S + \frac{1}{sC}} \cdot \frac{sC}{sC}$$

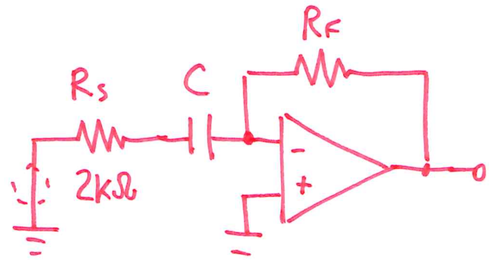
$$\frac{V_{out}}{V_{in}} = \frac{-sR_F C}{1 + sR_S C} \quad \begin{matrix} \} \text{ ZERO (SAME AS)} \\ \} \text{ POLE} \end{matrix}$$

$$\text{POLE} = \frac{-1}{2\pi R_S C} \quad \text{(NEW)}$$

SAME AS PURE DIFFERENTIATOR BELOW POLE $\frac{1}{2\pi R_S C}$

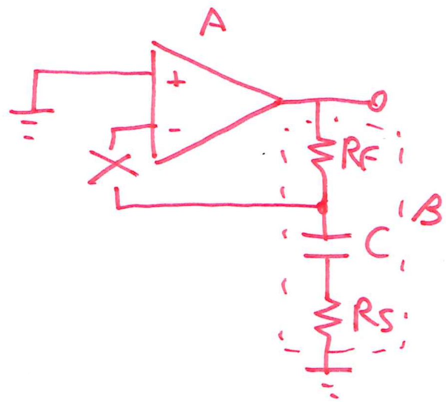
FINITE GAIN AT HIGH FREQUENCIES

Practical Differentiator: Loop Gain



1

Set all independent sources equal to zero



$$\beta(s) = \frac{R_S + \frac{1}{sC}}{R_S + \frac{1}{sC} + R_F} \cdot \frac{sC}{sC}$$

$$\beta(s) = \frac{1 + sR_sC}{1 + s(R_s+R_F)C}$$

ZERO β:

β POLE

2

Break feedback loop (don't change loading)

2A

Redraw in A, β format for clarity (optional)

ZERO: $f_z = \frac{1}{2\pi R_S C} = \frac{1}{2\pi (2k)(0.01\mu F)} = 8\text{ kHz}$ } NEW

POLE: $f_p = \frac{1}{2\pi (R_S+R_F)C} = \frac{1}{2\pi(102\text{ k}\Omega)(0.01\mu F)} = 158\text{ Hz}$ } $\approx$ SAME

3

Find

$|A|, |\beta| \quad \angle A, \angle\beta$

Practical Differentiator: Stability Analysis

1

Plot Loop Gain

$|A\beta| \angle A\beta$

2

Find f_1

Frequency at which $|A\beta| = 1$

3

Check $\angle A\beta$ at f_1

compared to -180°