Current-input Operational Amplifiers

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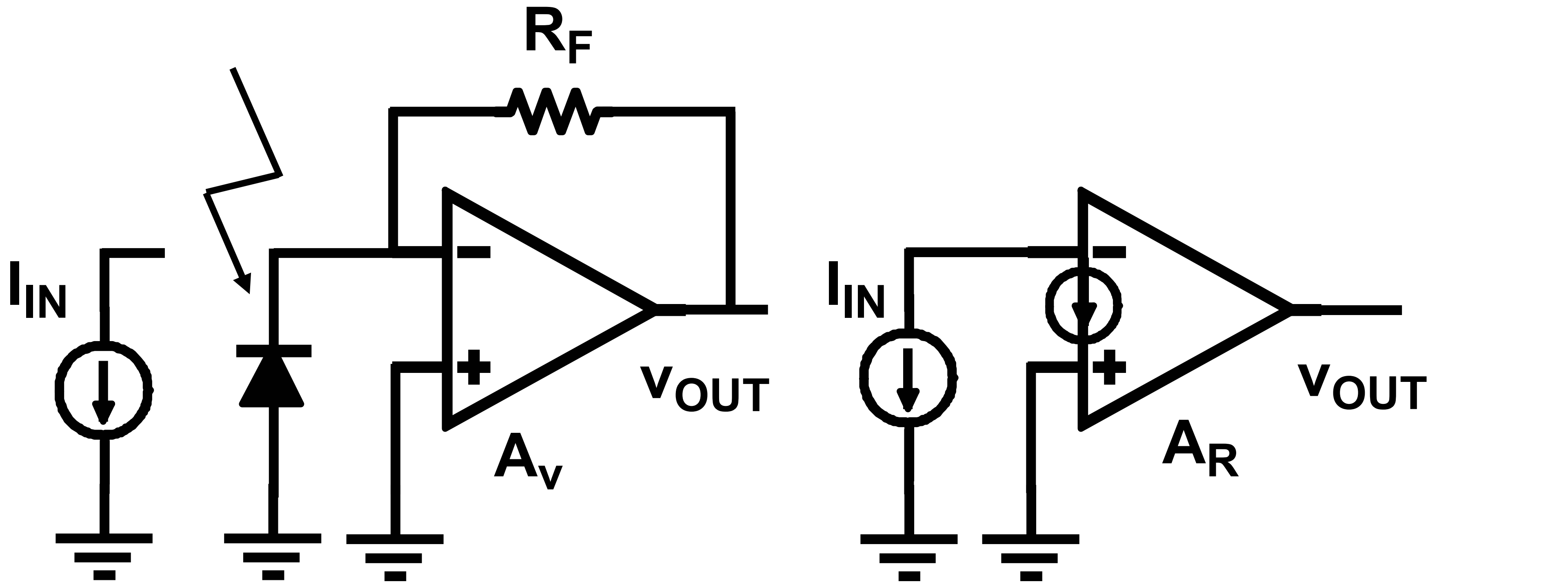
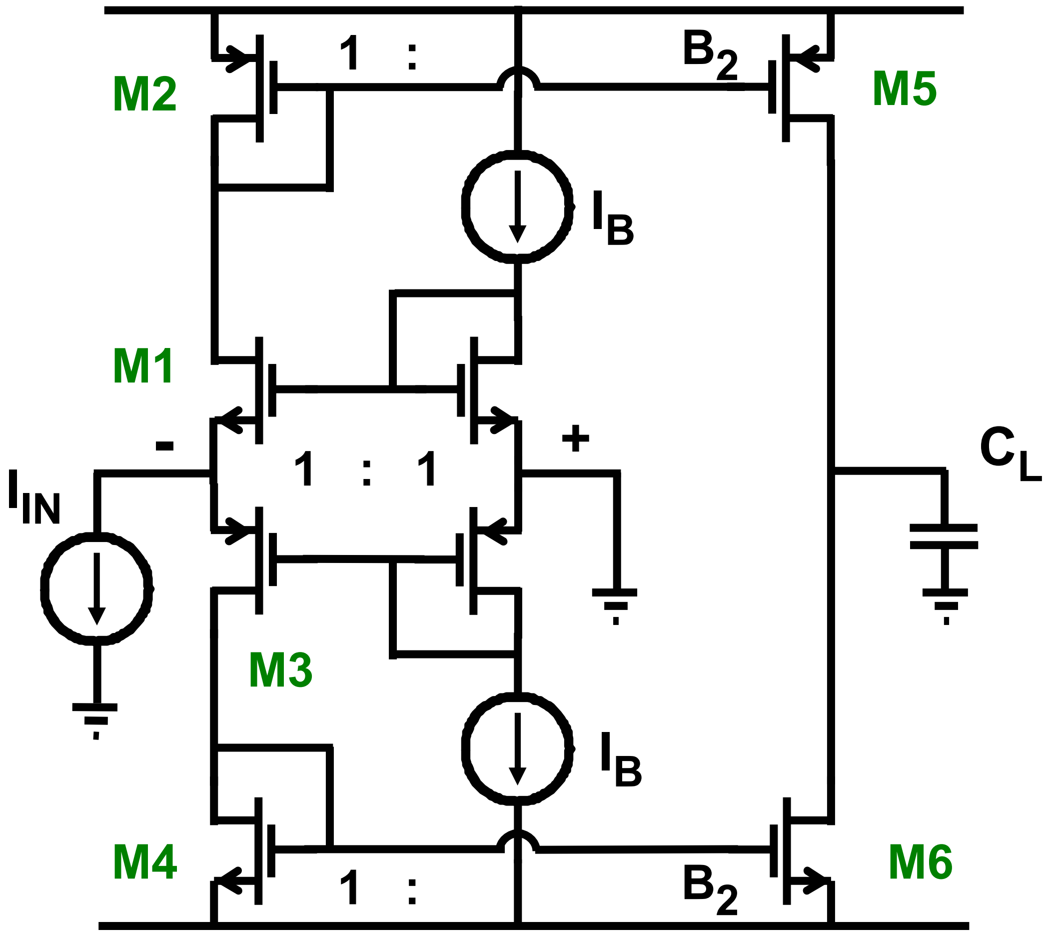
Current or voltage amplifier



$$v_{OUT} = R_F I_{IN}$$

$$v_{OUT} = A_R I_{IN}$$

Operational current amplifier Gain & Speed



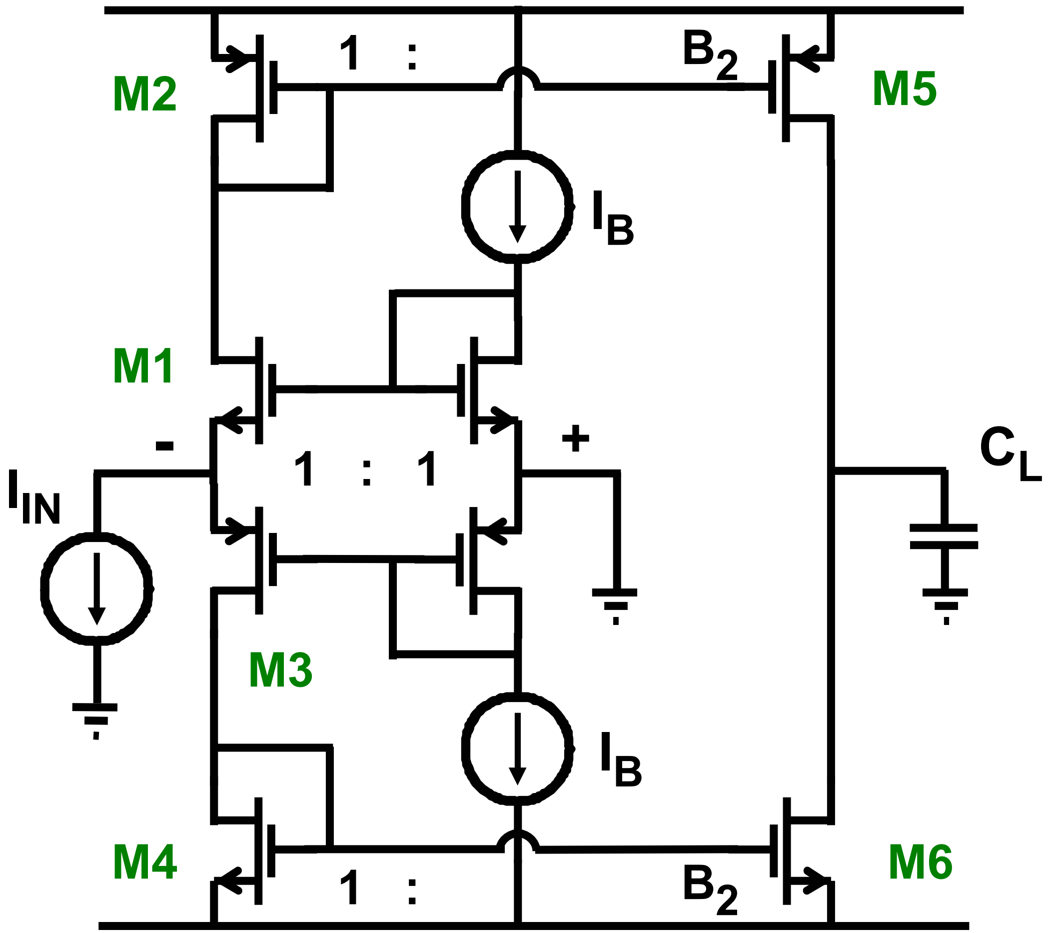
$$A_R = B_2 R_{OUT} = B_2\, r_{o5}//r_{o6}$$

$$BW = \frac{1}{2\pi\, C_L R_{OUT}} \sim I_{DS} \uparrow$$

$$A_R\, BW = \frac{B_2}{2\pi\, C_L}$$

$$SR = B_2 \frac{I_{IN}}{C_L} \qquad I_{DS} \uparrow$$

Operational current amplifier : noise



$$SR = B_2 \frac{I_{IN}}{C_L} \qquad I_{DS} \uparrow$$

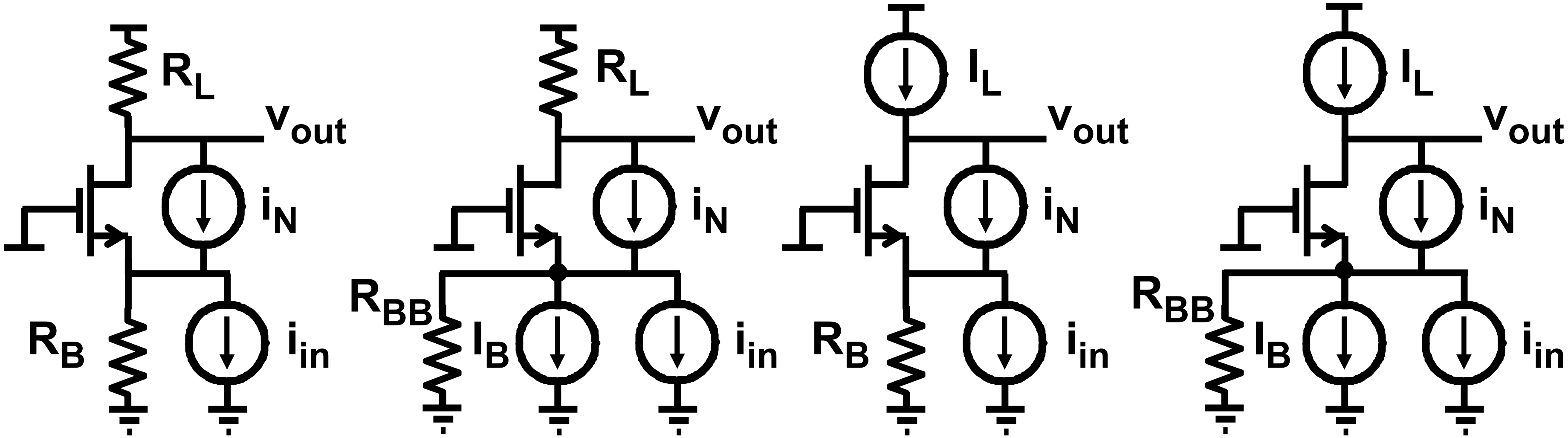
$$\overline{di_{DS}^2} = 4kT \frac{2}{3} g_m \, df$$

$$\overline{di_{IN}^2} \approx 2 \, \overline{di_{DS}^2}$$

$$\frac{S}{N} = \frac{I_{IN}}{\sqrt{\overline{di_{IN}^2} \, BW \, \frac{\pi}{2}}}$$

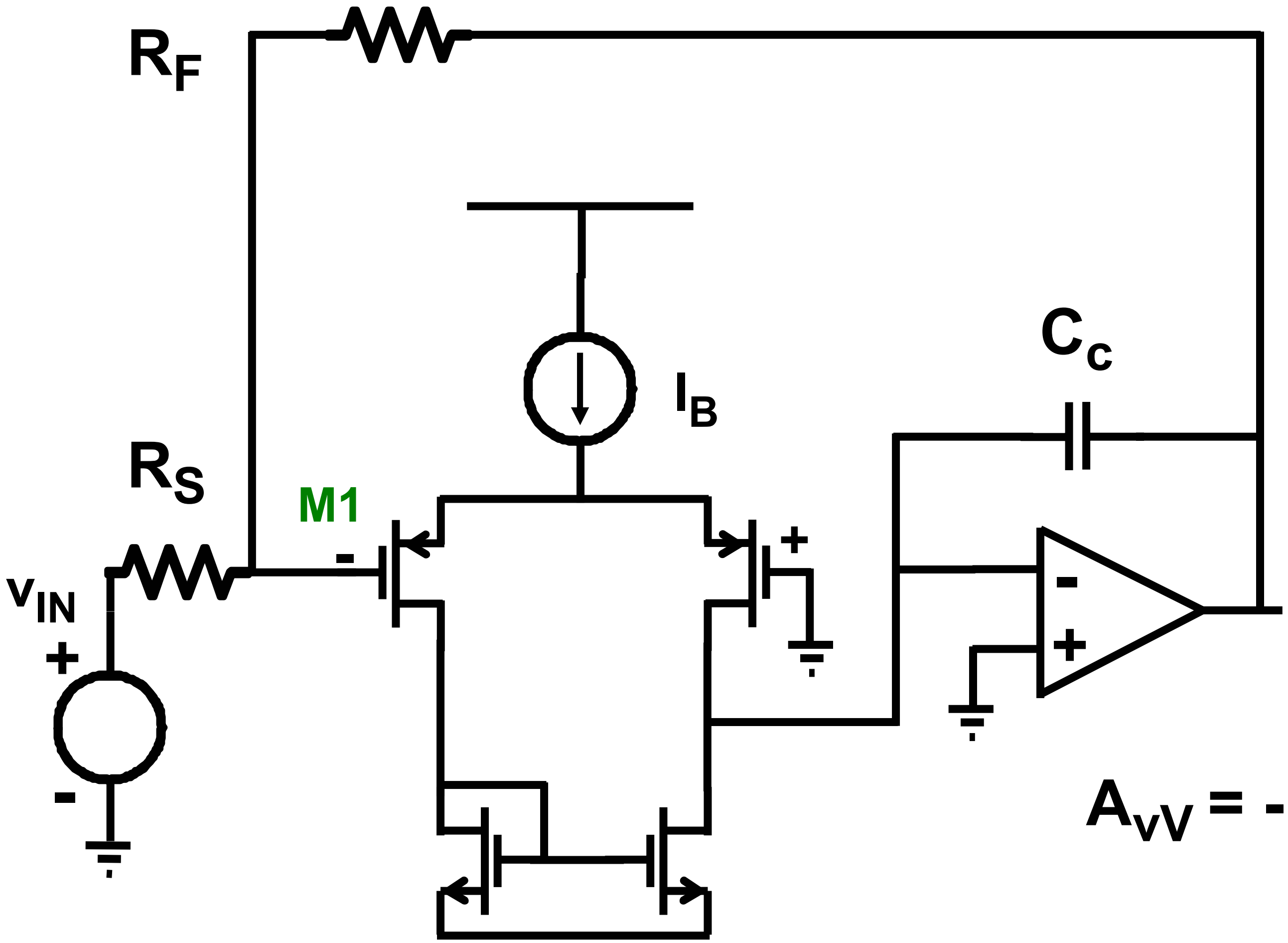
$$\frac{S}{N} \sim \frac{I_{IN}}{\sqrt{I_{DS}}} \qquad I_{DS} \downarrow$$

Gain and noise in MOST cascodes



	$r_{DS} > R_L$	$R_{BB} > R_L$	$g_m r_{DS} > 1$	
$\frac{v_{out}}{i_{in}}$	$g_m R_L \frac{R_B}{1+g_m R_B}$	R_L	$g_m r_{DS} R_B$	$g_m r_{DS} R_{BB}$
$\frac{v_{out}}{i_N}$	$\frac{R_L}{1+g_m R_B}$	$\frac{R_L}{g_m R_{BB}}$	R_B	r_{DS}
$\frac{i_{in}}{i_N}$	$\frac{1}{g_m R_B}$	$\frac{1}{g_m R_{BB}}$	$\frac{1}{g_m r_{DS}}$	$\frac{1}{g_m R_{BB}}$

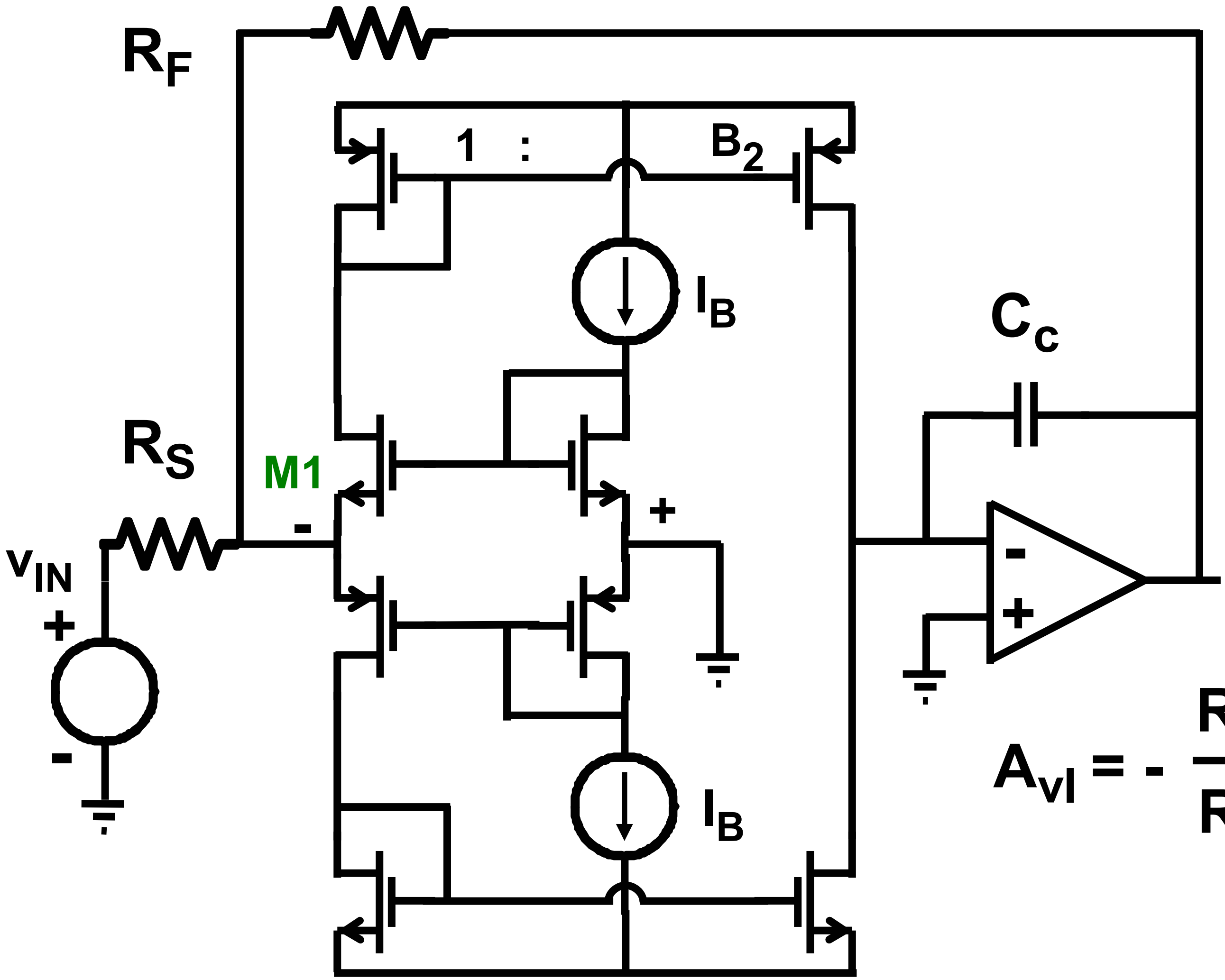
OTA in feedbackloop



$$GBW = \frac{g_{m1}}{2\pi\, C_c}$$

$$A_{vV} = -\frac{R_F}{R_S}\,\frac{1}{1+\frac{R_F}{R_S}\frac{j\omega C_c}{g_{m1}}}$$

OCA in feedbackloop

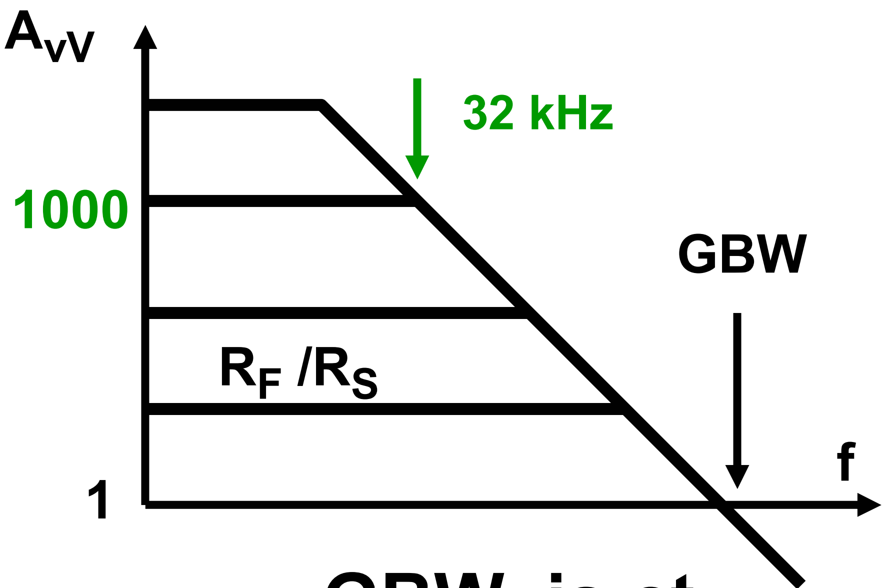


$$A_{vl} = -\frac{R_F}{R_S}\,\frac{1}{1+\frac{R_F}{R_S}\,j\omega R_S C_c}$$

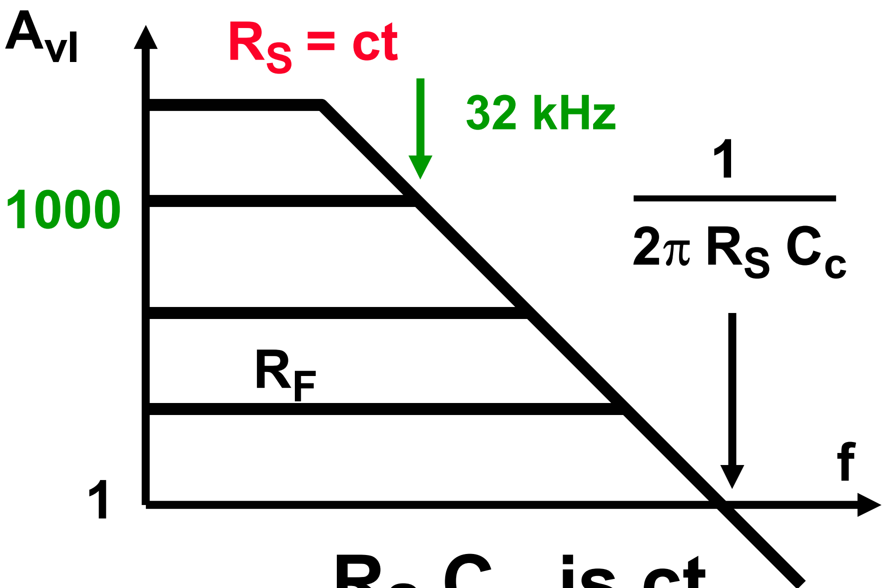
Comparison A_{vV} and A_{vI}

$$A_{vV} = -\frac{R_F}{R_S}\,\frac{1}{1 + \frac{R_F}{R_S}\,\frac{j\omega C_c}{g_{m1}}}$$

$$A_{vI} = -\frac{R_F}{R_S}\,\frac{1}{1 + \frac{R_F}{R_S}\,j\omega\, R_S\, C_c}$$



GBW is ct

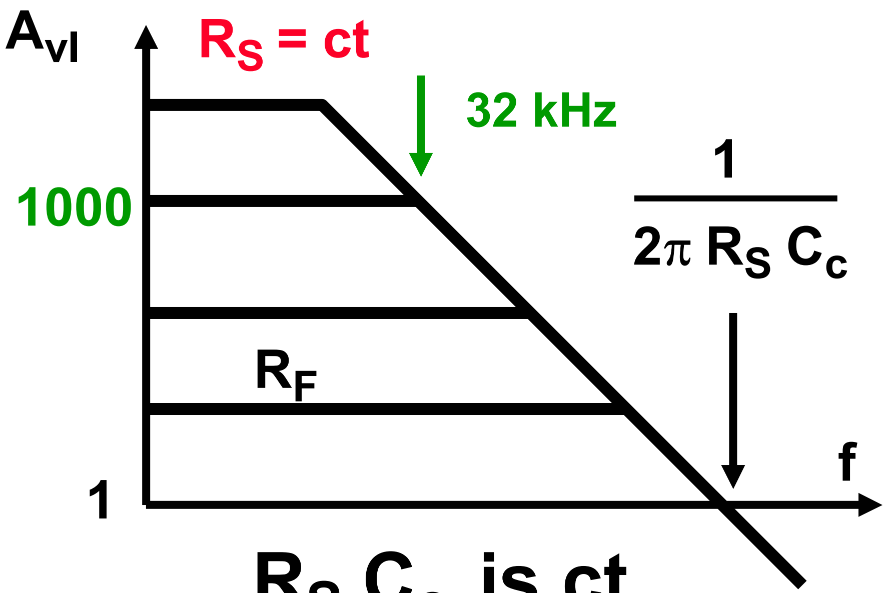


$R_S C_c$ is ct

g_{m1} = 0.2 mS; C_c = 1 pF; GBW = 32 MHz; A_{vV} = 1000; BW = 32 kHz

Advantage A_{vl}

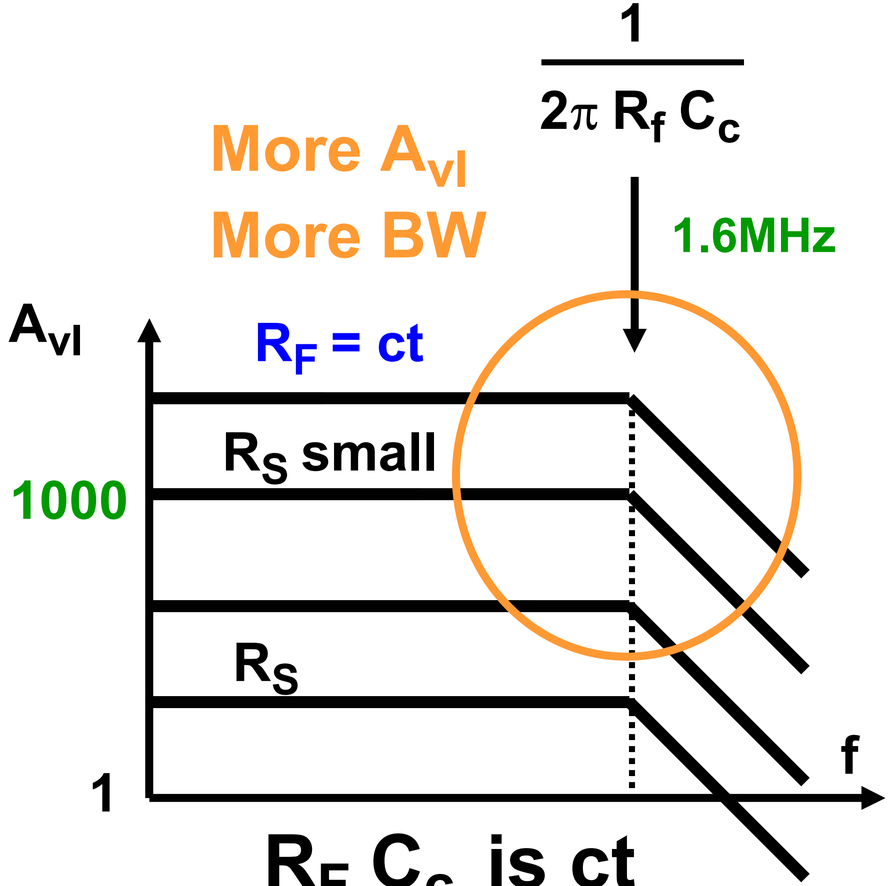
$$A_{vl} = -\frac{R_F}{R_S}\,\frac{1}{1 + \frac{R_F}{R_S}\, j\omega R_S C_c}$$



$R_S C_c$ is ct

More A_{vl}

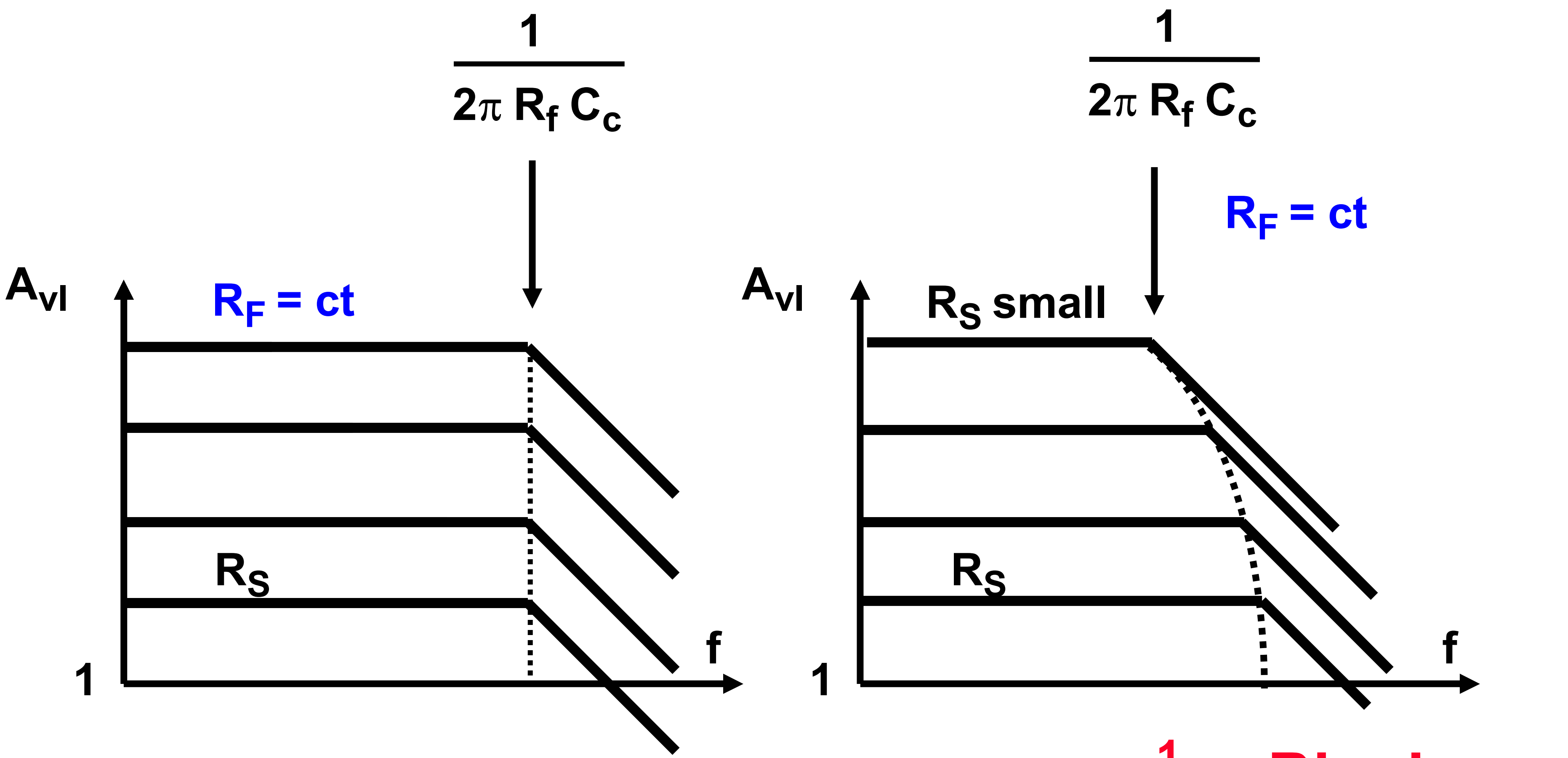
More BW



$R_F C_c$ is ct

C_c =1 pF; R_S = 100 Ω; R_F = 100 k Ω; BW = 1.6MHz

Limitations advantage A_{vI}



R_S limited to $R_S + \frac{1}{2g_{m1}}$: **Bipolar**

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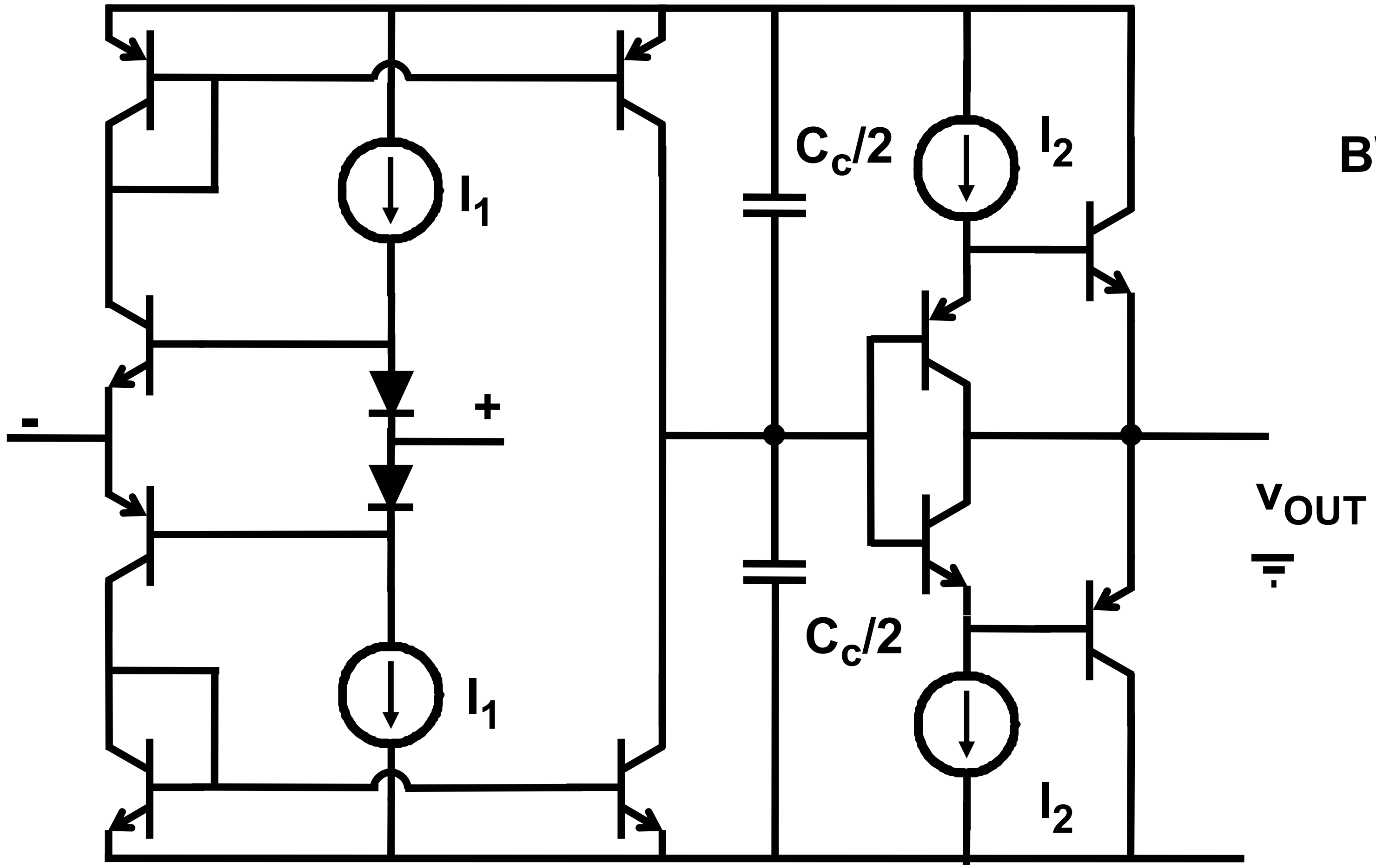
Single-stage OCA- 1 (AD846)

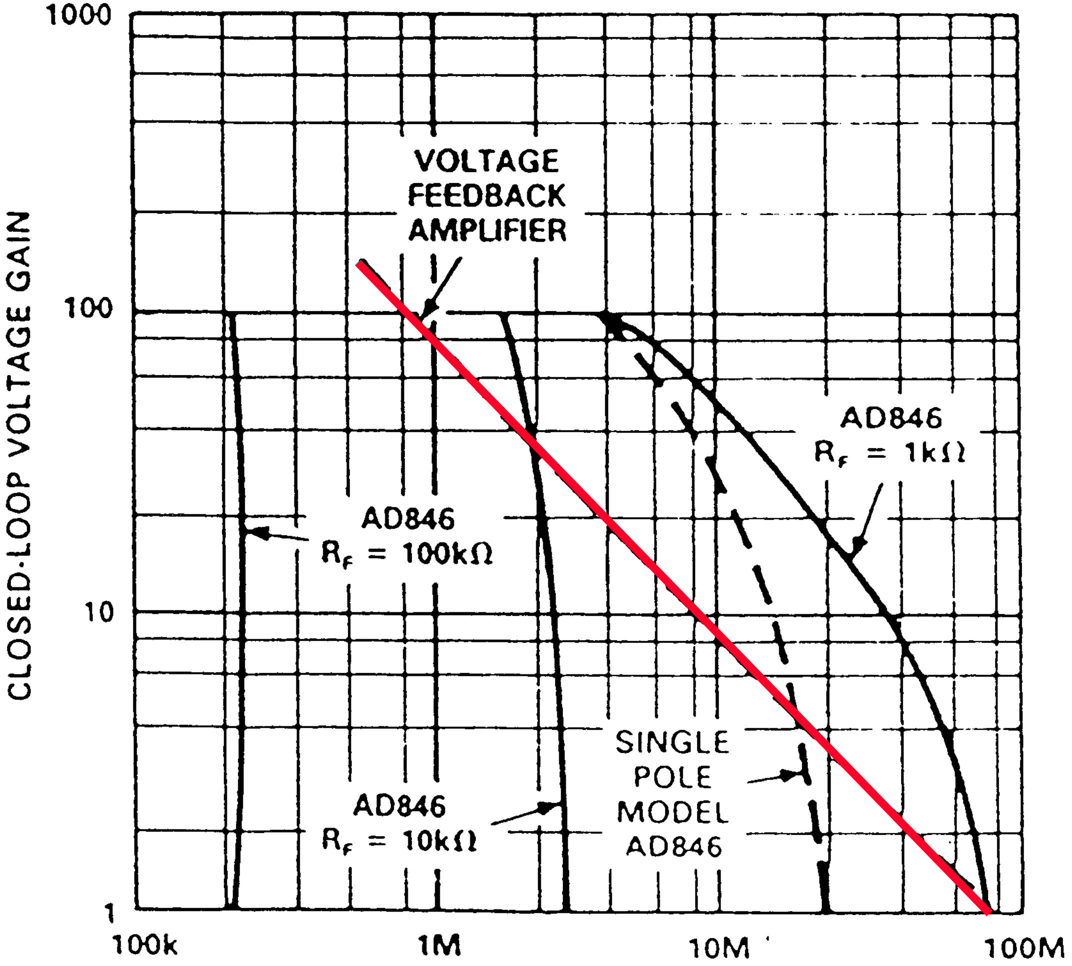


BW = 80 MHz

SR (G=1) = 450 V/μs

6.5 mA (5V)
0.45 μA

Single-stage OCA- 2 (AD846)



R_F = 100 kΩ

A = 10 : R_S = 10 kΩ

A = 100 : R_S = 1 kΩ

R_F = 10 kΩ

A = 10 : R_S = 1 kΩ

A = 100 : R_S = 100 Ω

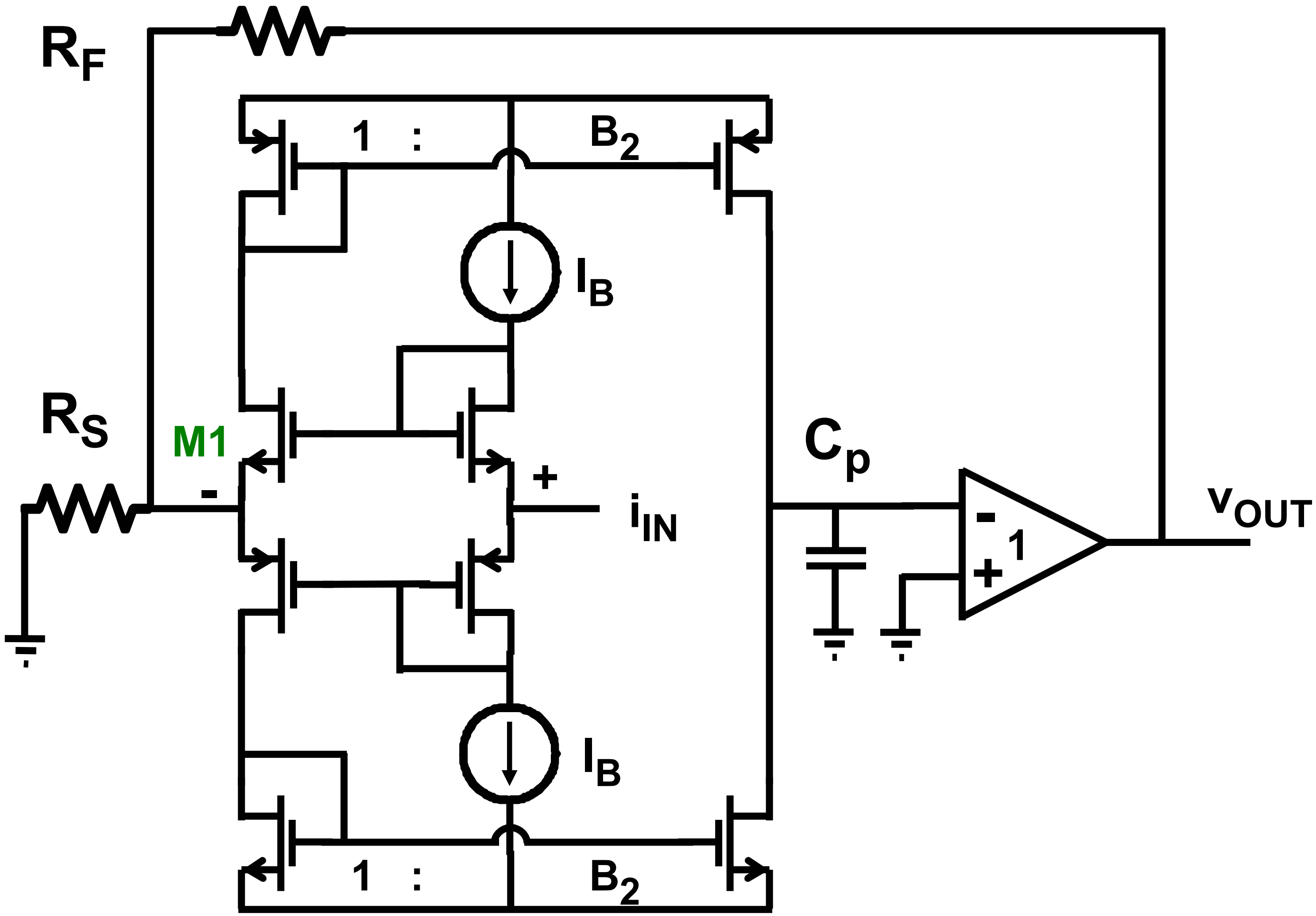
R_F = 1 kΩ

A = 10 : R_S = 100 Ω

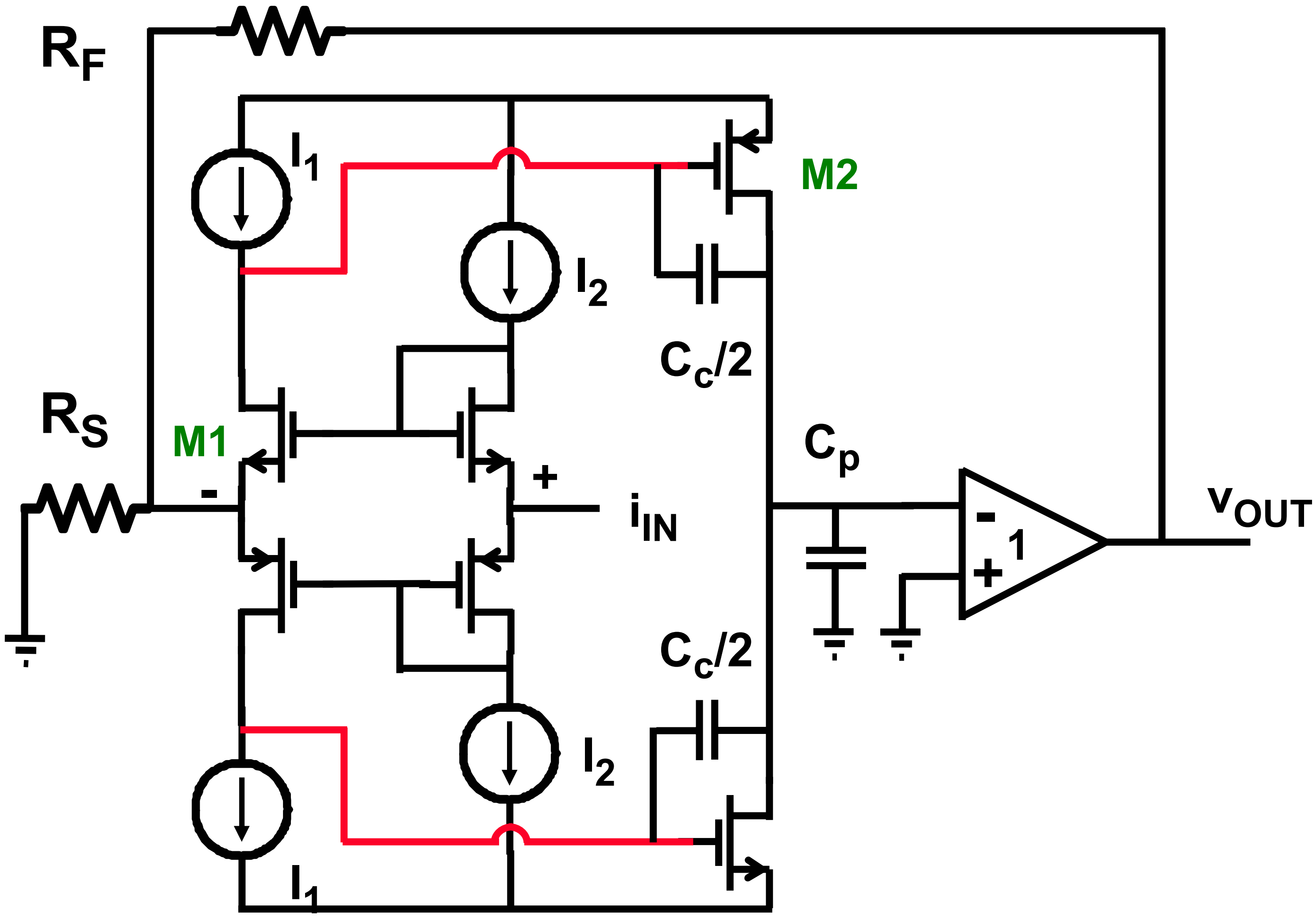
A = 100 : R_S = 10 Ω

$$R_S + \frac{1}{g_{m1}} > 10\ \Omega$$

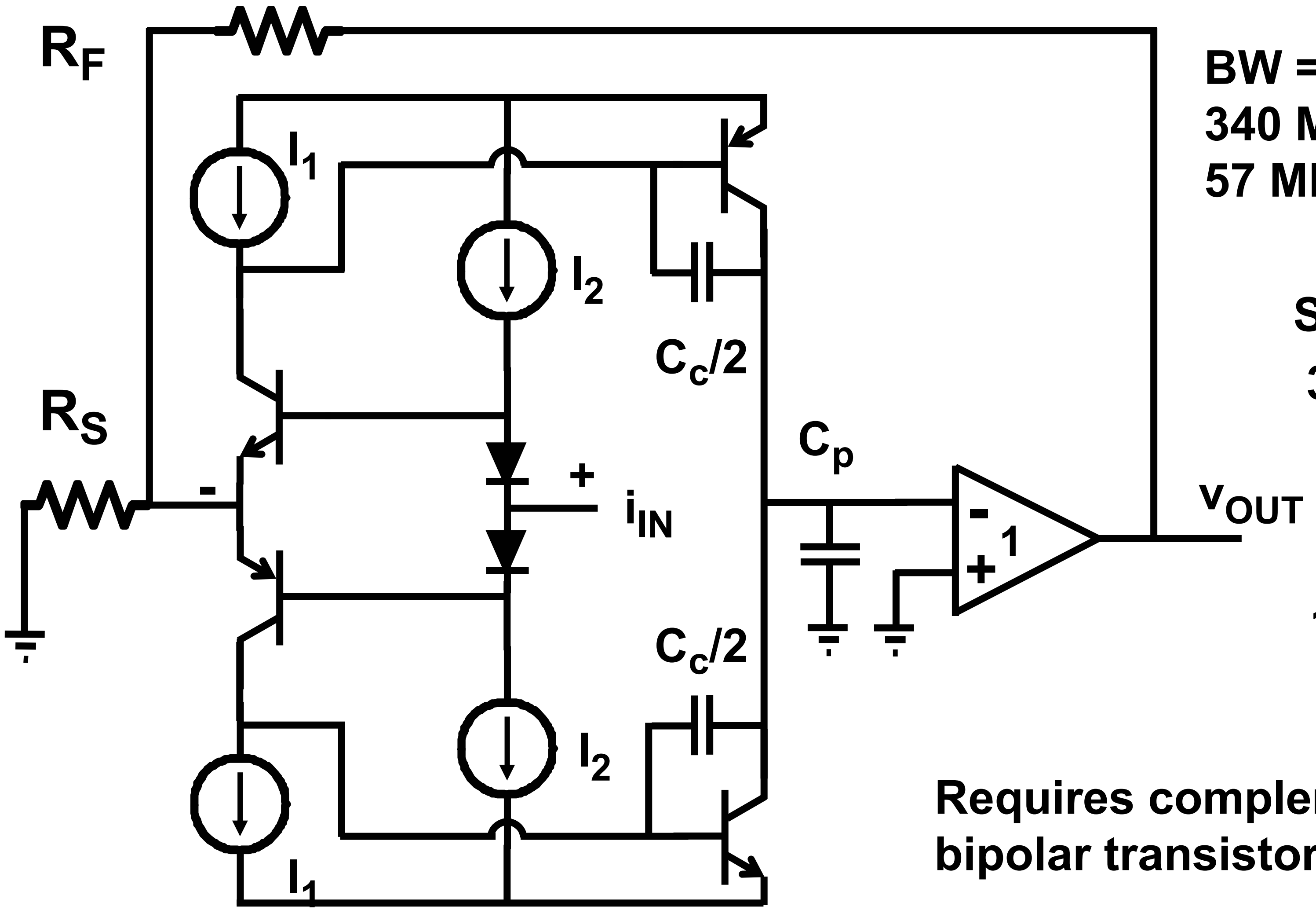
Two-stage OCA- 1 (AD8011 bipolar)



Two-stage OCA- 2 (AD8011 bipolar)



Two-stage OCA :AD8011



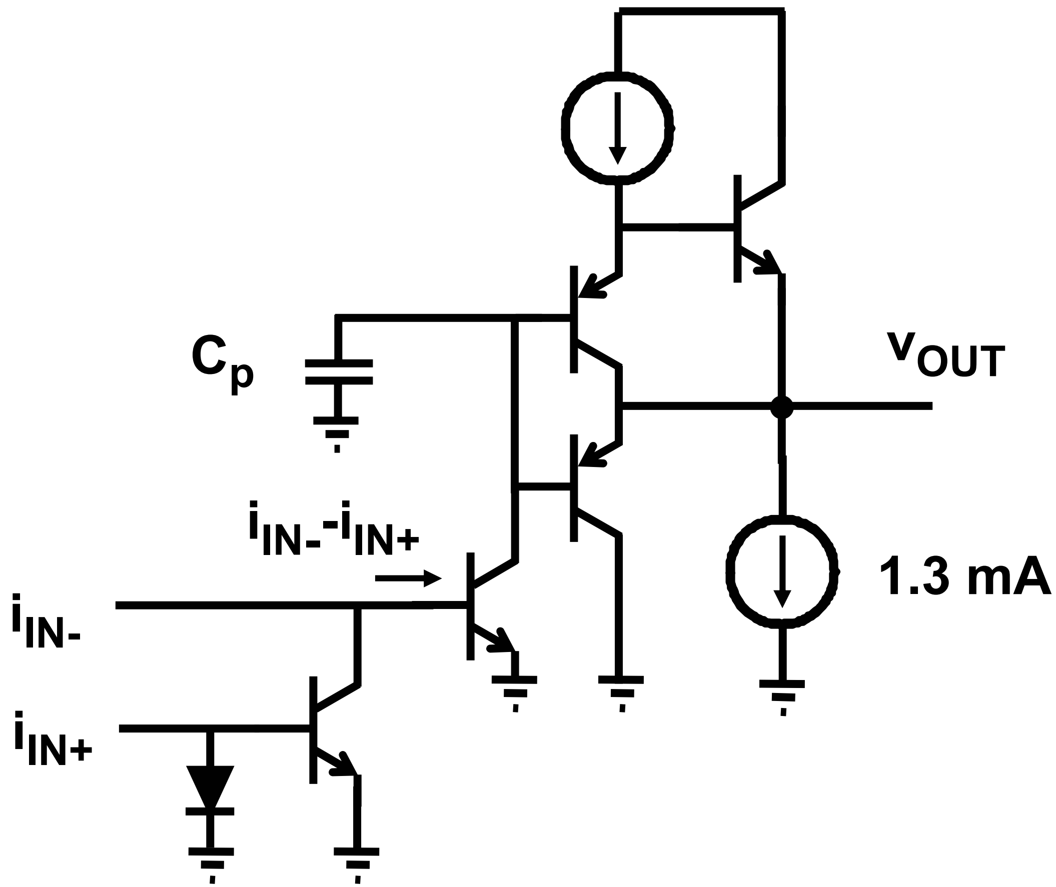
BW =
340 MHz (G=1)
57 MHz (G=10)

SR (G=1)
3500 V/μs

1 mA (5V)
15 μA

Requires complementary bipolar transistor process

Two-stage OCA (LM3900)

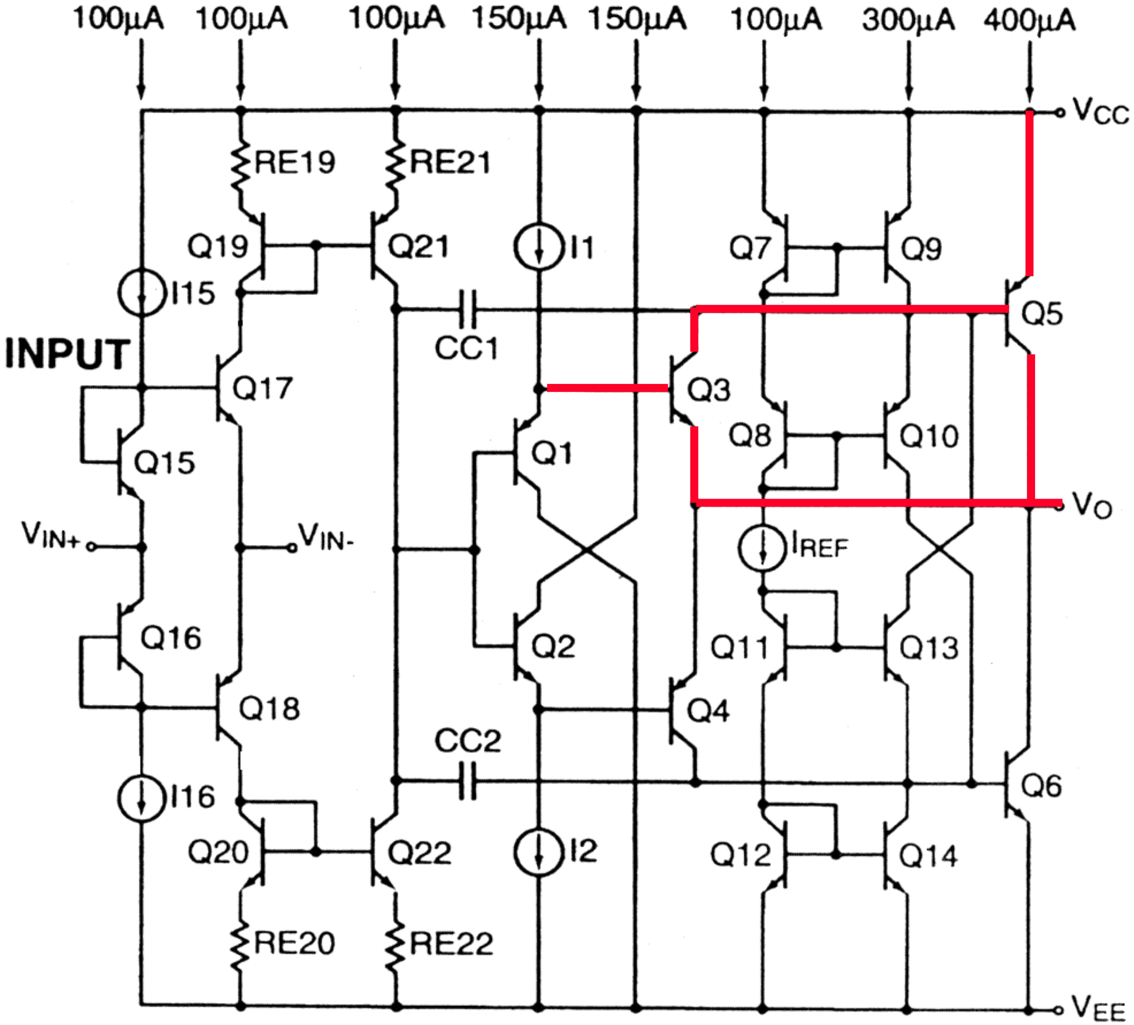


GBW = 2.5 MHz

SR (G=1) =
0.5 V/μs

1.4 mA (4-36V)
0.03 μA

Current feedback opamp



110 MHz/ 1.5 mA

230 V/µs

A_v = 2 in 100 Ω

f_T = 3.8 GHz

Ref.Bales, JSSC
Sept. 97, 1470-1474

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