Lab. 13 Example solution

DESIGN AND CHARACTERIZATION OF FULL-DIFFERENTIAL OPA

1. Design of full-differential OPA

Folded-cascode differential amplifier

$GBP = 40\text{MHz} \qquad CL = 1.0\text{pF}$

$$gm1 = \sqrt{2\beta_1 I_{DS1}} = GBP \cdot CL = 2\pi \cdot 40\text{MHz} \cdot 1.0\text{pF} = 251\text{uS}$$

$$\beta_1 = \frac{gm1^2}{2I_{DS1}}$$

$$\left(\frac{W}{L}\right)_1 = \frac{1}{\mu_n C_{OX}} \frac{gm1^2}{2I_{DS1}} = \frac{1}{98\text{uA/V}^2} \frac{(251\text{uS})^2}{2 \cdot 10\text{uA}} = 32.1 \approx 32 = \frac{64}{2} = \left(\frac{16}{2}\right) \cdot 4$$

CMFB

When the input voltages V_{in}^+ and V_{in}^- are equal to the common mode voltage, the output voltage of CMFB must be close to the gate voltage of M9 and M10 of the full-differential amplifier. Therefore, when the bias current of M5-M12 is the same as M9 and M10, the size of M5-M12 of the CMFB can be set at the same size as M9 and M10 of the full-differential amplifier.

1. Design of full-differential OPA

Folded-cascode differential amplifier

MOSFET	L(m)	W(m)	M	AD, AS(m^2)	PD, PS(m)	W/L
M1, M2	2u	16u	4	48p	22u	32
M3, M4, M7-M10	2u	10u	3	30p	16u	15
M5, M6, M11-M13	2u	10u	1	30p	16u	5

CMFB

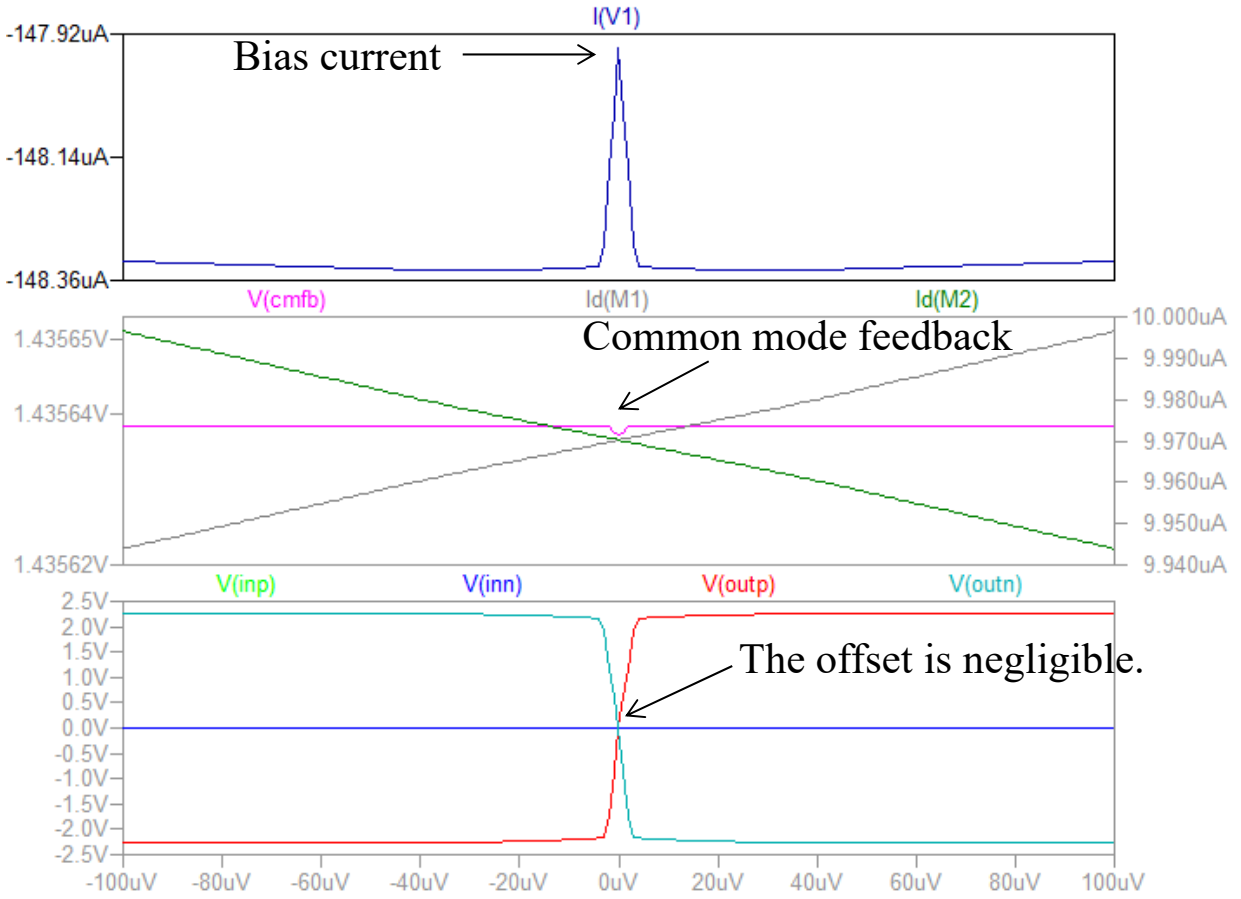
MOSFET	L(m)	W(m)	M	AD, AS(m^2)	PD, PS(m)	W/L
M1-M4	2u	16u	8	48p	22u	64
M5-M12	2u	10u	3	30p	16u	15
M13-M16	2u	10u	1	30p	16u	5

Table III

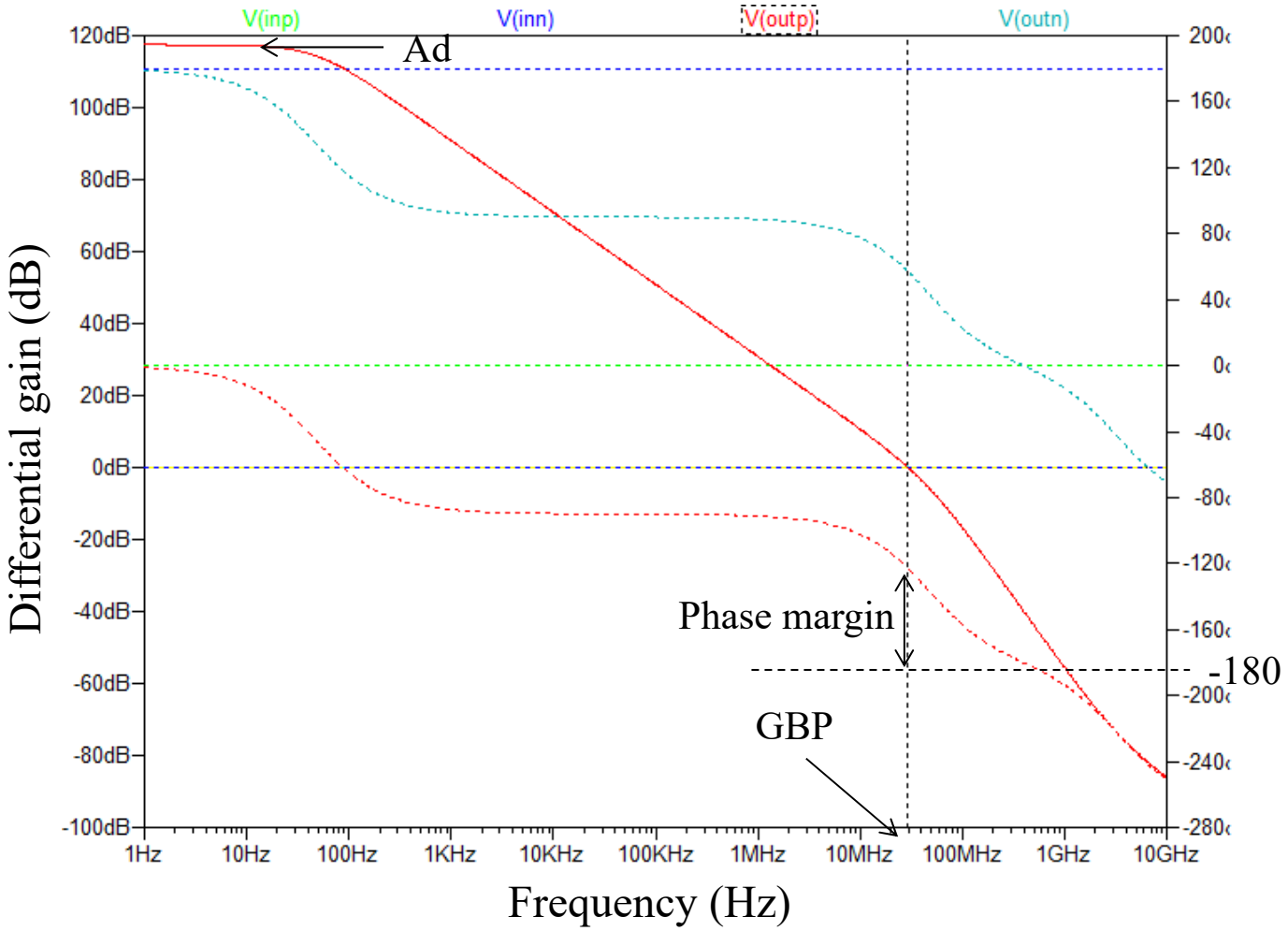
- The specification estimated by the simulation.

Parameter	Unit	Value	Remarks
GBP	Hz	29.5MEG	CL = 1.0pF
A_d	dB	117	@ 10Hz
Phase Margin	degree	56.9	
Slew Rate	V/us	11.1	CL = 1.0pF
Total Bias Current	A	148.0u	
Reference Current	A	9.97u	$I_{SS}/2$

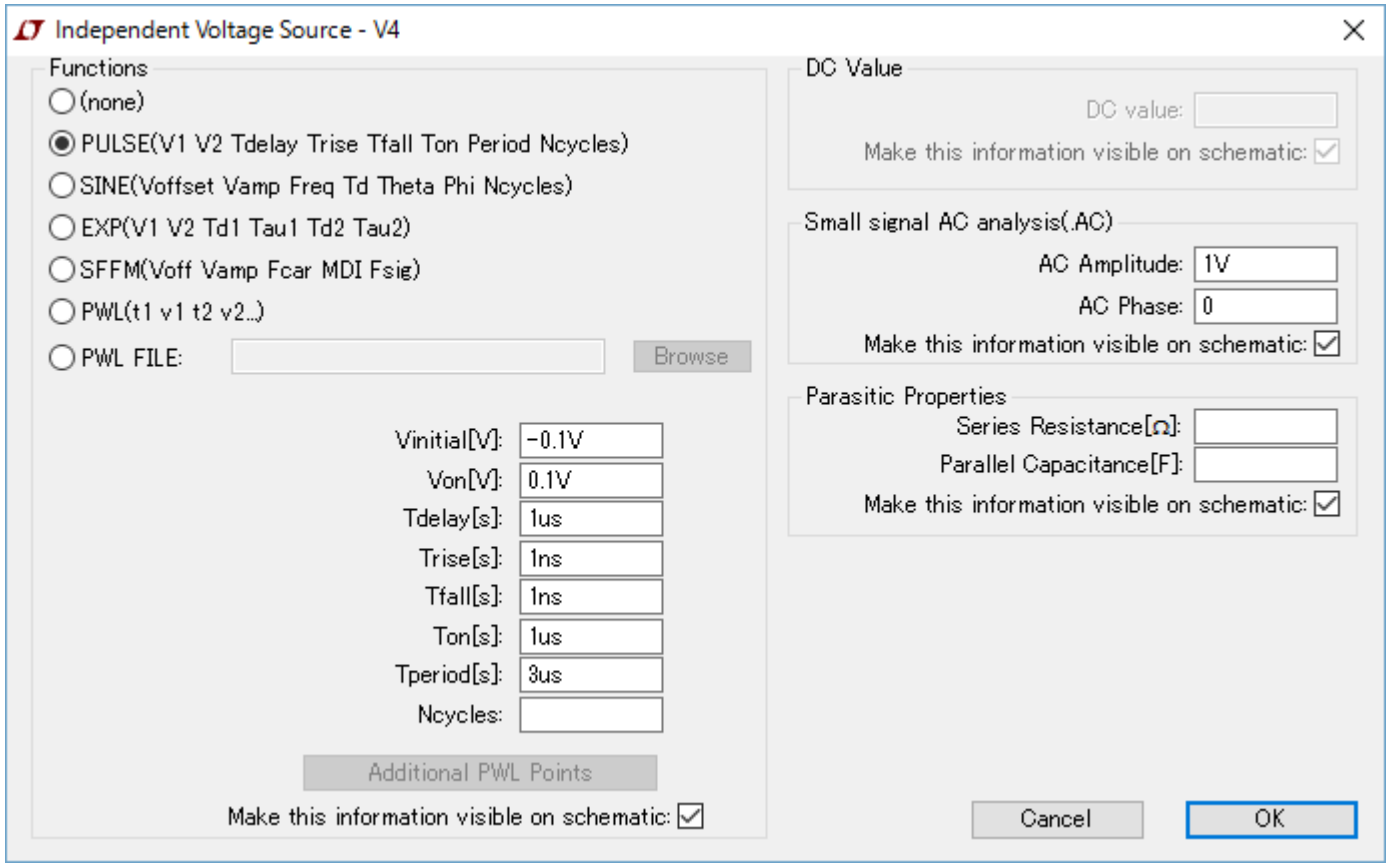
DC characteristic



AC characteristic



Input pulse



Note: Select none as a function and set the DC value at zero before the AC analysis.

TRAN response