帯域幅 2

TIプレシジョン・ラボ – オペアンプ

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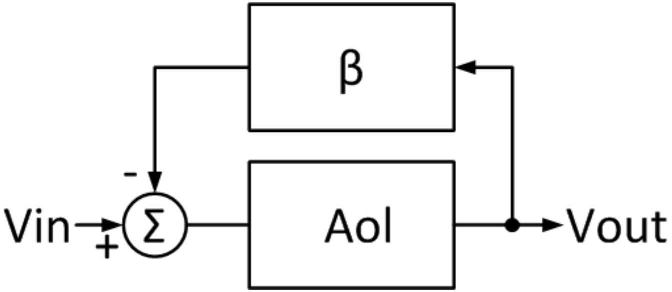
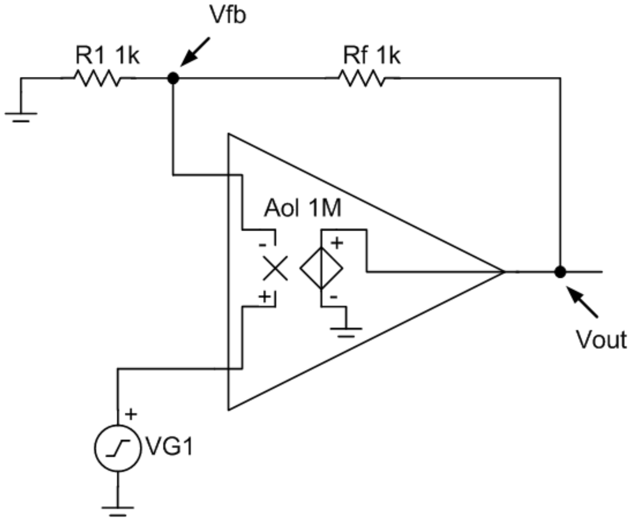
オペアンプ帯域幅





A_{ol} = Open loop Gain

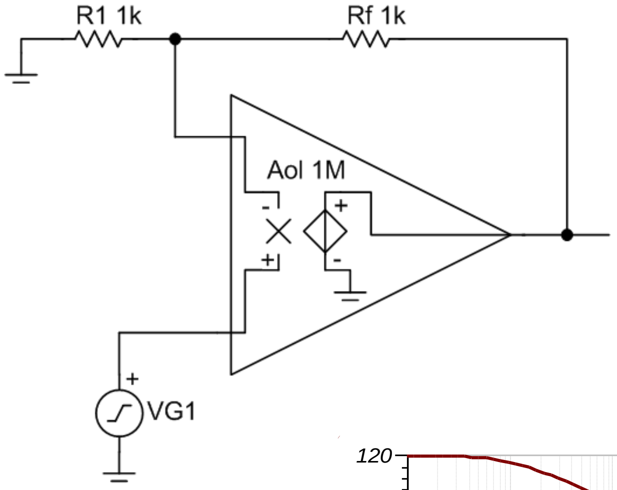
$$\beta = \text{Feedback Factor} = \frac{V_{fb}}{V_{out}} = \frac{R_1}{R_1 + R_f}$$

$$A_{cl} = \text{Closed Loop Gain} = \frac{A_{ol}}{1 + A_{ol}\beta}$$

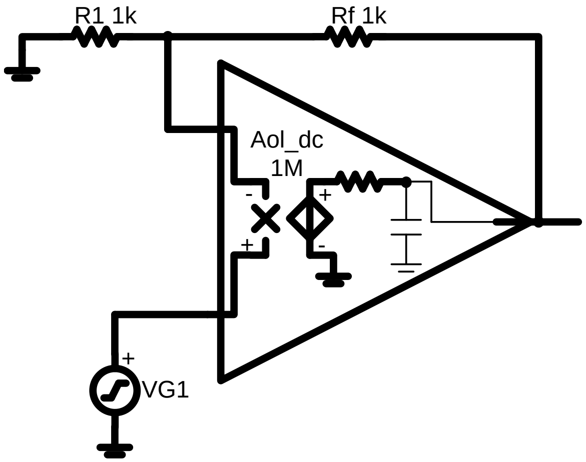
$A_{ol}\beta$ = Loop Gain

$$A_{cl} = \lim_{A_{ol}\beta \to \infty}\left(\frac{A_{ol}}{1 + A_{ol}\beta}\right) = \frac{1}{\beta} = 1 + \frac{R_f}{R_1}$$

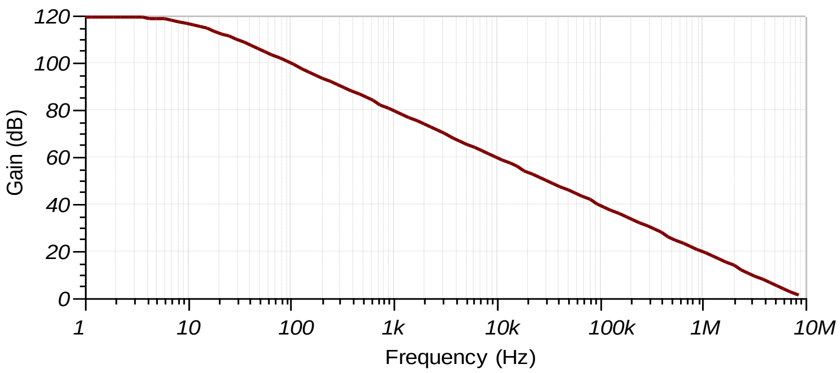
オペアンプ帯域幅



R1 1k
Rf 1k
Aol 1M
VG1

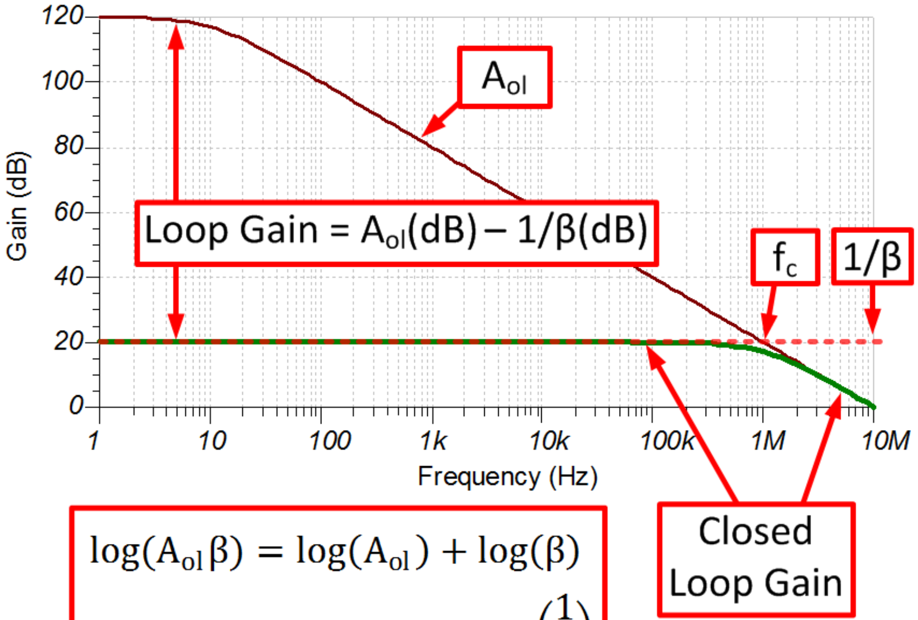


R1 1k
Rf 1k
Aol_dc
1M
VG1



Gain (dB)
120
100
80
60
40
20
0
1
10
100
1k
10k
100k
1M
10M
Frequency (Hz)

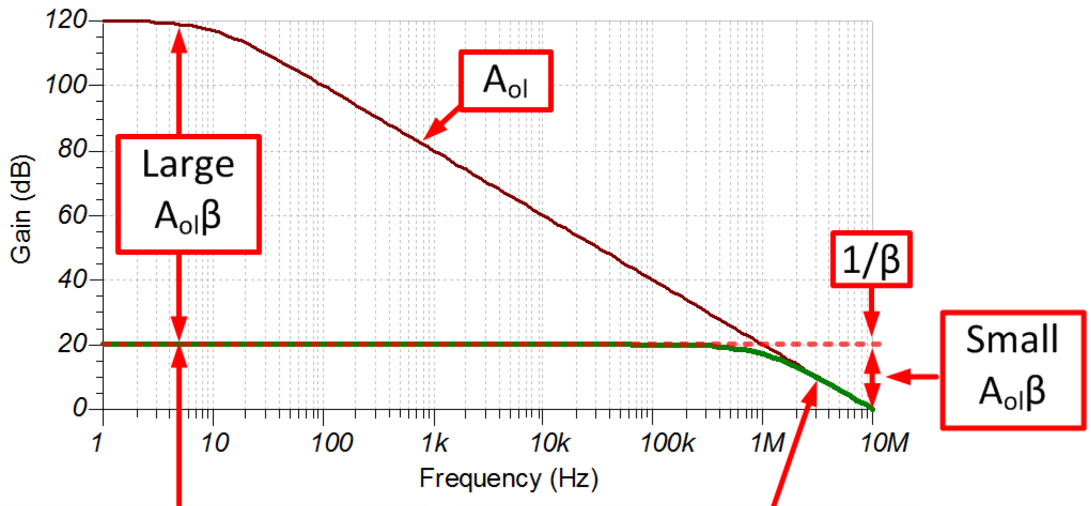
ループ・ゲイン、閉ループ・ゲイン& A_{ol}



$$\log(A_{ol}\beta) = \log(A_{ol}) + \log(\beta)$$

$$\log(A_{ol}\beta) = \log(A_{ol}) - \log\left(\frac{1}{\beta}\right)$$

ループ・ゲイン、閉ループ・ゲイン& A_{ol}



A_{cl} = 1/β for Large $A_{ol}β$

$$A_{cl} = \lim_{A_{ol}\beta\to\infty}\left(\frac{A_{ol}}{1 + A_{ol}\beta}\right) = \frac{1}{\beta} = 1 + \frac{R_f}{R_1}$$

A_{cl} = A_{ol} for Small $A_{ol}β$

$$A_{cl} = \lim_{A_{ol}\beta\to 0}\left(\frac{A_{ol}}{1 + A_{ol}\beta}\right) = A_{ol}$$

帯域幅　製品仕様例

PARAMETER		CONDITIONS	STANDARD GRADE OPA827AI			HIGH GRADE OPA827I[(1)(2)]			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
FREQUENCY RESPONSE									
Gain-Bandwidth Product	GBW	G = +1		22			22		MHz

$$GBW = Gain \cdot BW$$

In this example, for any gain from 0dB to Avol.

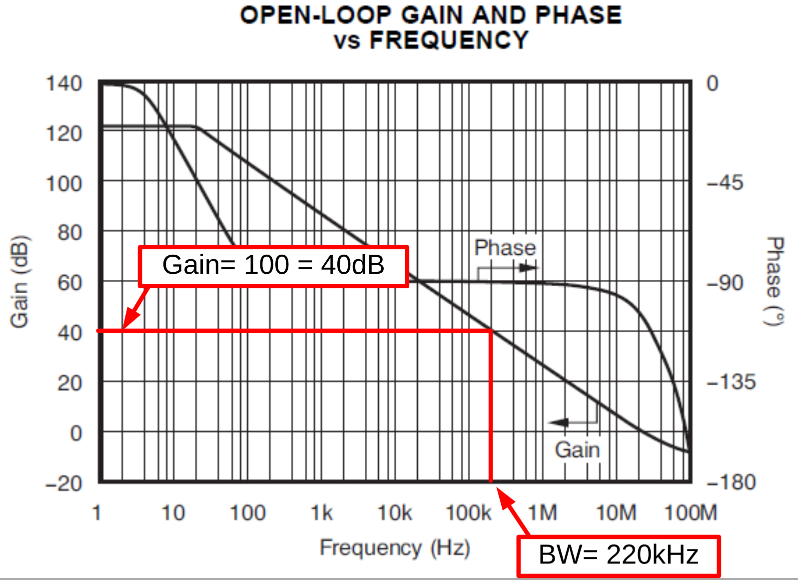
where
GBW -- Gain Bandwidth in Hz
Gain -- closed loop voltage gain
BW -- Bandwidth in Hz

For example

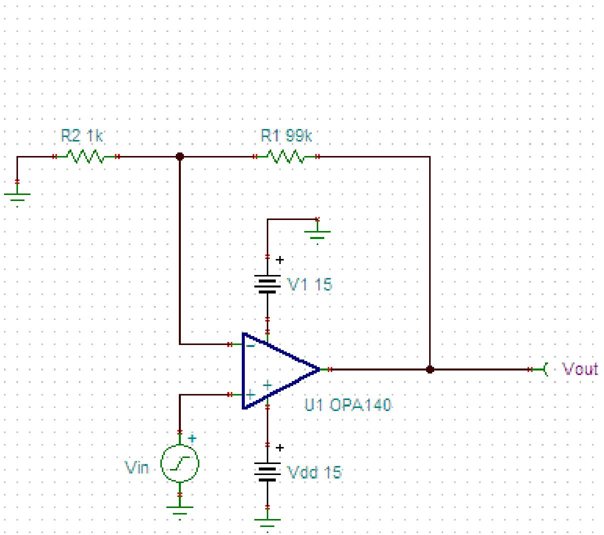
$$Gain = 100$$

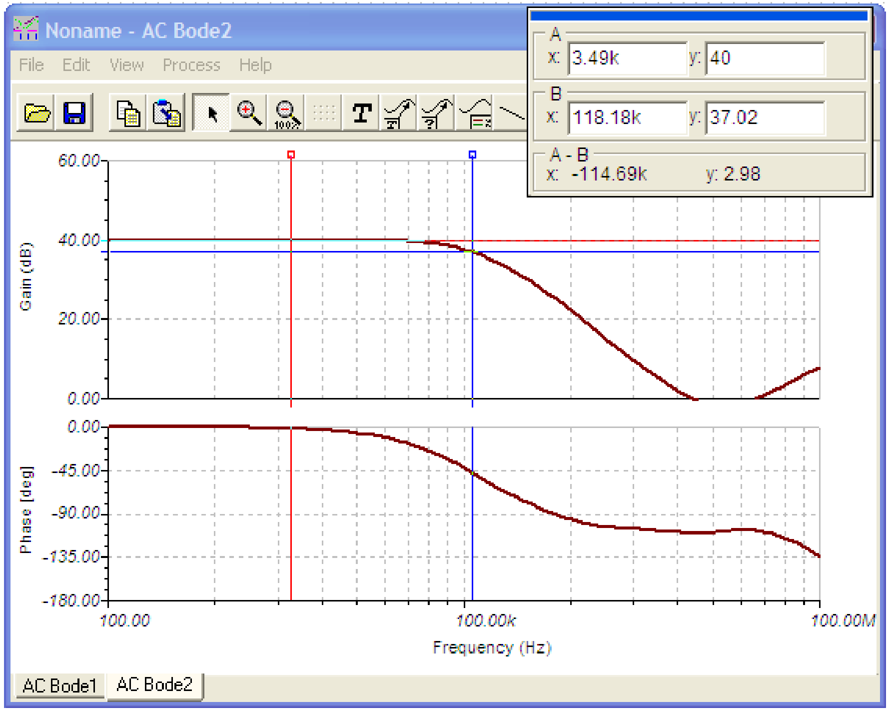
Closed Loop Bandwidth is calculated:

$$BW = \frac{GBW}{Gain} = \frac{22MHz}{100} = 220kHz$$



シミュレーション：Non-inverting Gain of 100V/V





Simulated_BW = 118kHz

$$BW = \frac{GBW}{Gain} = \frac{11MHz}{100} = 110kHz$$

帯域幅 vs. I_q

Op Amp	Typical GBW	Typical Iq
OPA369	12kHz	0.8uA
OPA333	350kHz	17uA
OPA277	1MHz	790uA
OPA129	1MHz	1.2mA
OPA827	22MHz	4.8mA
OPA350	38MHz	5.2mA
OPA211	45MHz (Gain=1)	3.6mA
OPA835	51MHz (Gain=1)	250uA
OPA847	600MHz (Gain=12)	18.1mA

帯域幅 vs. I_q

BIPOLAR

$$g_m = \frac{q \cdot I_c}{k \cdot T}$$

$$r_{gm} = \frac{1}{g_m}$$

$$BW = \frac{g_m}{2 \cdot \pi \cdot C_c} = \frac{1}{2 \cdot \pi \cdot C_c \cdot r_{gm}}$$

$$BW = \frac{q \cdot I_c}{2 \cdot \pi \cdot C_c \cdot k \cdot T}$$

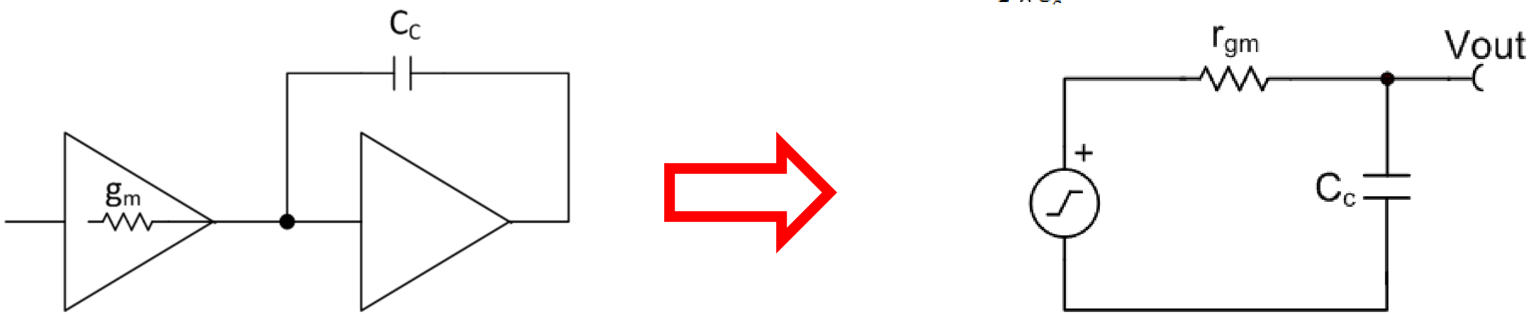
MOSFET

$$g_m = \sqrt{2 \cdot I_D \cdot \mu \cdot C_{ox} \cdot \frac{W}{L}}$$

$$r_{gm} = \frac{1}{g_m}$$

$$BW = \frac{g_m}{2 \cdot \pi \cdot C_c} = \frac{1}{2 \cdot \pi \cdot C_c \cdot r_{gm}}$$

$$BW = \frac{\sqrt{2 \cdot I_D \cdot \mu \cdot C_{ox} \cdot \frac{W}{L}}}{2 \cdot \pi \cdot C_c}$$



ありがとうございました