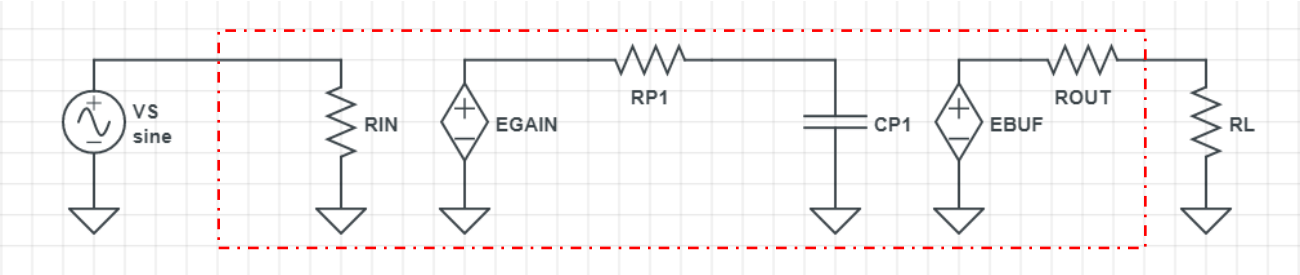
General Parameters

A_{ol}	1e4 = 80 dB
UGF	10 MHz
R_{FB}	9 KΩ (4K, 9K for parametric sweep)
R	1 KΩ
DC input	1 V
ac input	sine wave : 1 V amplitude and 1 KHz frequency
time step	period/50

Deliver 1 : Op-Amp Subcircuit

Op-Amp model has three basic stages

1. diff amplifier with high voltage gain - R_{IN}, EGAIN
2. A single pole low pass filter - R_{P1}, C_{P1}
3. An output buffer - EBUF, R_{OUT}



Hand Analysis :

As A_{Ol} is provided by $EGAIN = A_{ol} = 10^4 = 80\ dB$ and the first pole

Fig.1. Op-Amp Sub-Circuit

frequency f_{p1} is given by the relation [1]

$$f_{p1} = \frac{1}{2\pi\, R_{p1} C_{p1}} = \frac{UGF}{A_{ol}} \qquad [1]$$

and with $A_{ol} = 10^4\ and\ UGF = 10\ MHz$ the cut off frequency $f_{p1} = 1\ KHz$ choose $R_{p1} = 1\ K\Omega$

$$\therefore C_{p1} = \frac{10^4}{10 * 10^6} * \frac{1}{2\pi * 1K} = 0.15915\ uF$$

Assume $R_{IN} = 100\ M\Omega$ and $R_{OUT} = 10\ \Omega$ and $R_L = 1\ K\Omega$

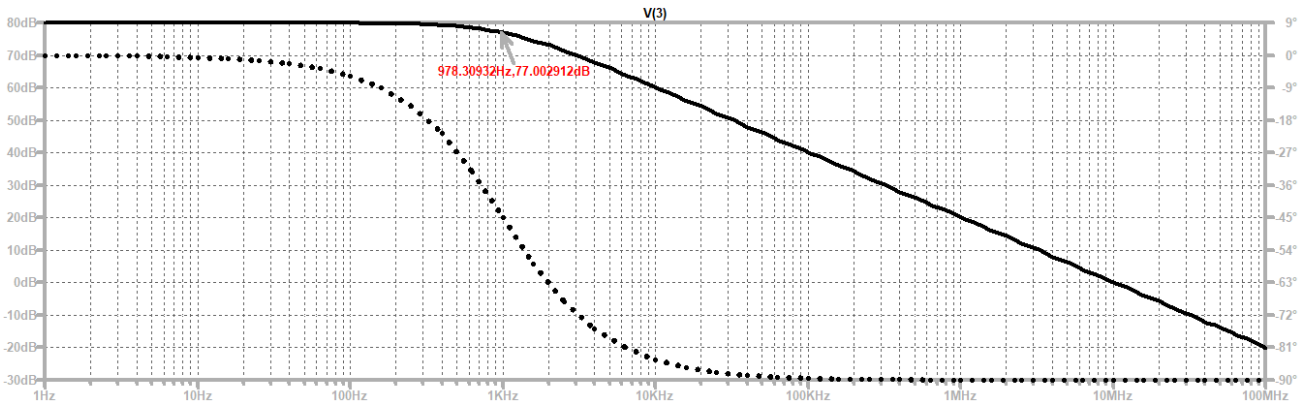


Fig.2. Op-Amp Model AC analysis

Sub-Circuit Netlist

```
SpiceOPAMP.CIR
*
* use ac input sine wave with 1V peak value and f = 1 KHz
VS   1    0    AC   1    SIN(0VOFF 1VPEAK    1KHZ)
* Define the model terminals
XOP 1 0 3    OPAMP
* use 1 Kohm as load resistance
RL   3    0    1k
*
* OPAMP MACRO MODEL, SINGLE-POLE
* connections:       non-inverting input
*                    |    inverting input
*                    |    |    output
*                    |    |    |
.SUBCKT OPAMP        1    2    6
* INPUT IMPEDANCE
RIN 1    2    100MEG
* DC GAIN=10K AND UMITY GAIN=10MHZ
* UNITY GAIN = DCGAIN X POLE1
EGAIN    3 0 1 2 10K
* assume Rp1 = 1K
RP1 3    4    1K
* POLE1 = 1/(2*pi*RP1*CP1)
CP1 4    0    0.15915UF
* OUTPUT BUFFER AND RESISTANCE
EBUFFER 5 0 4 0 1
ROUT     5    6    10
.ENDS
*
* ANALYSIS
.AC      DEC      5 1 100MEG

.END
```