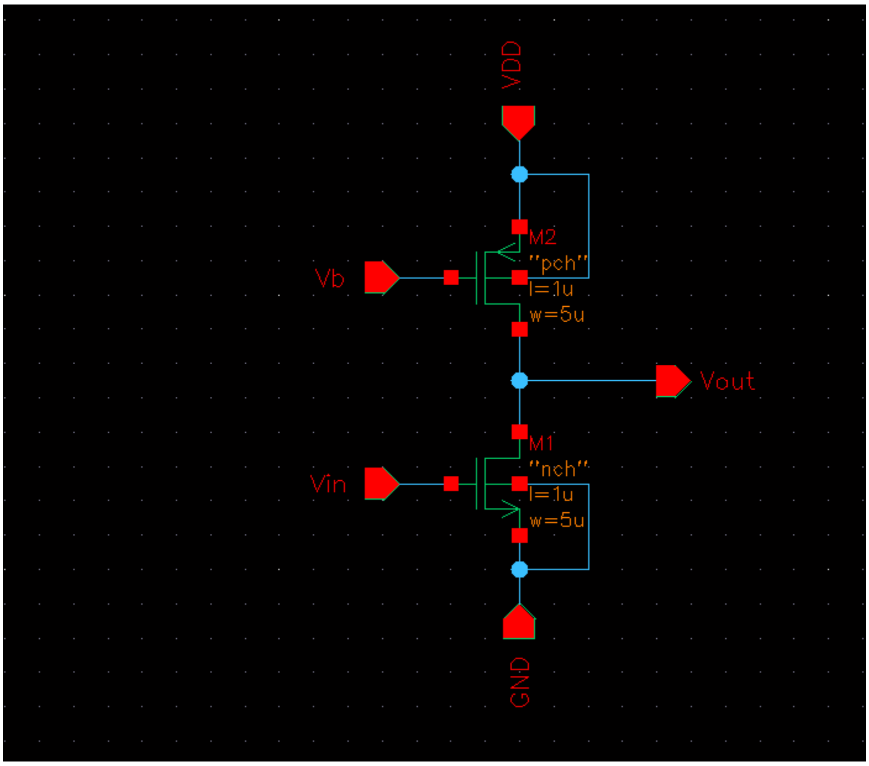
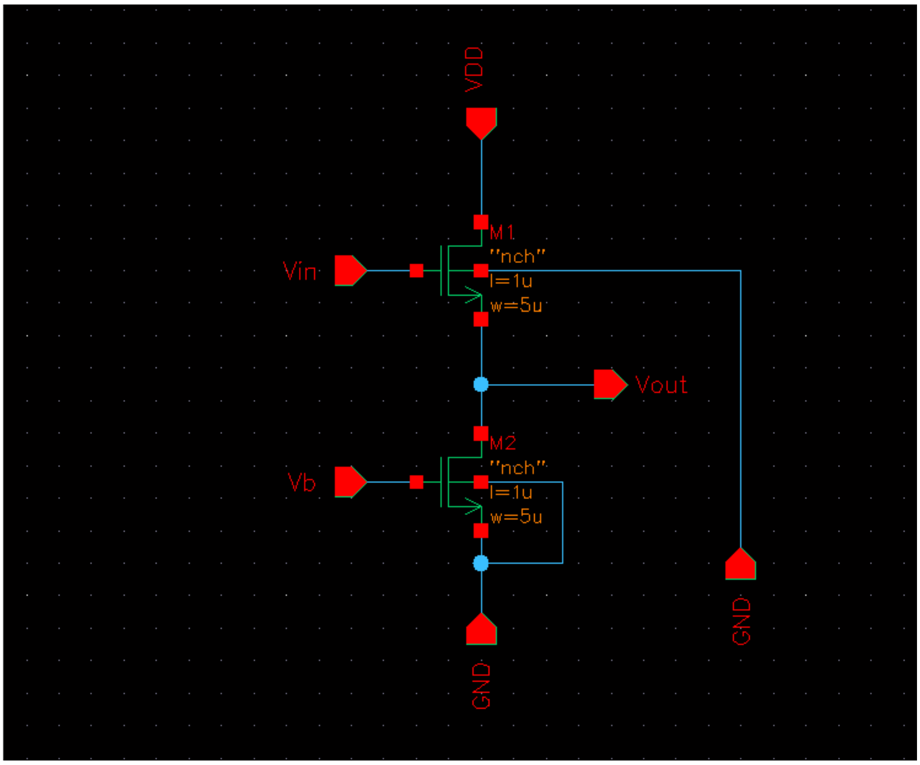
Analog IC Design & Analysis Homework 4 陳彥廷 102061146

1. Composer：

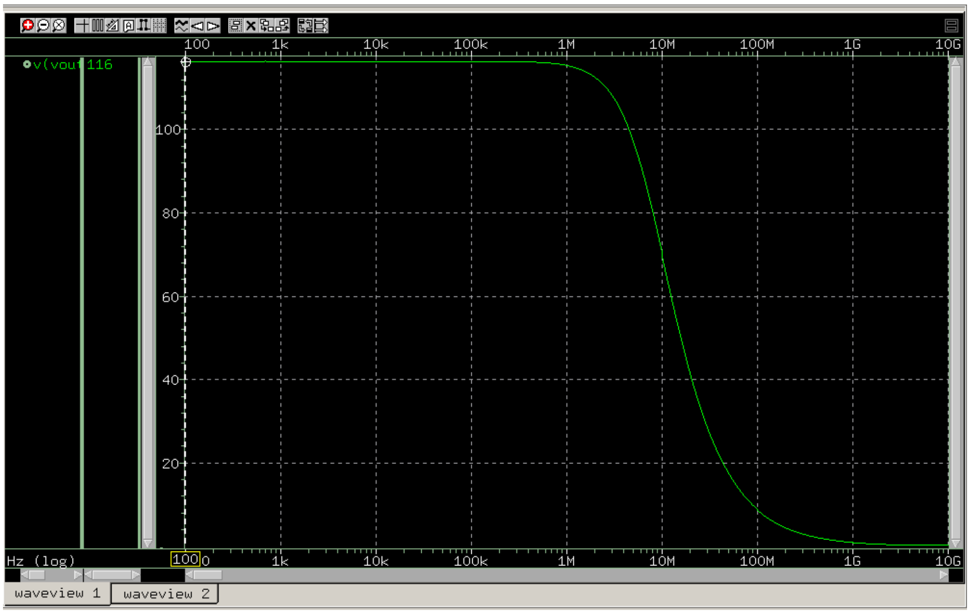


(a) Common-source stage



(b) Source follower

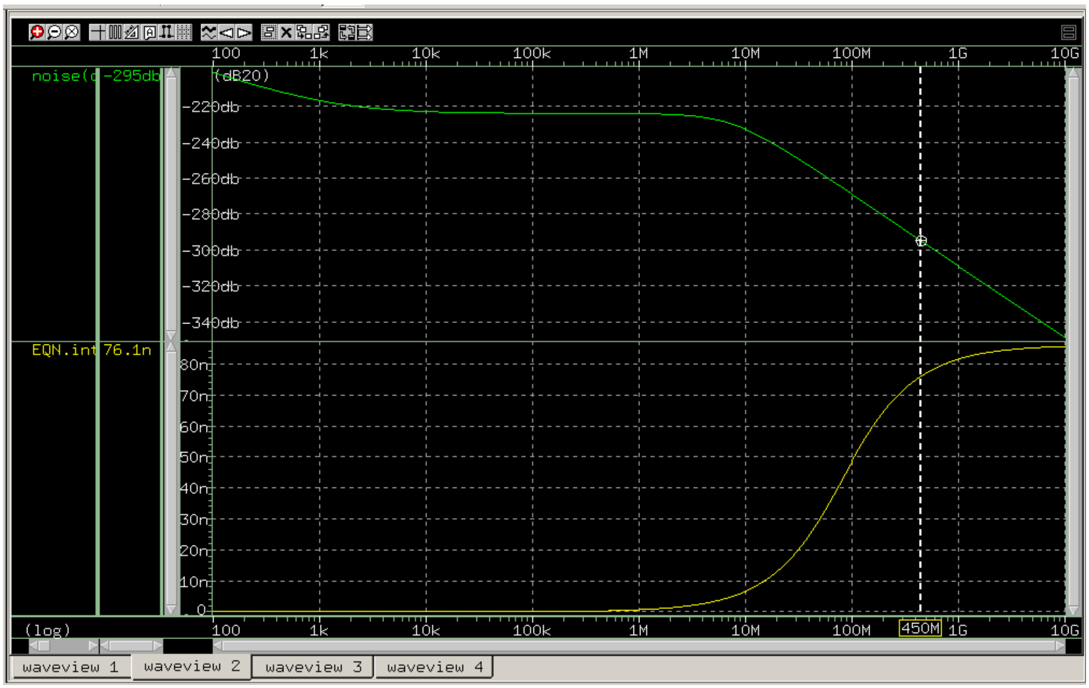
(a) The common-source amplifier generates the gain that equals 116 V/V with the corner frequency ≒ 3.6 kHz and the pole frequency of the thermal noise ≒ 4.5 MHz. The plot is as followed：(including the gain and output noise plot.)



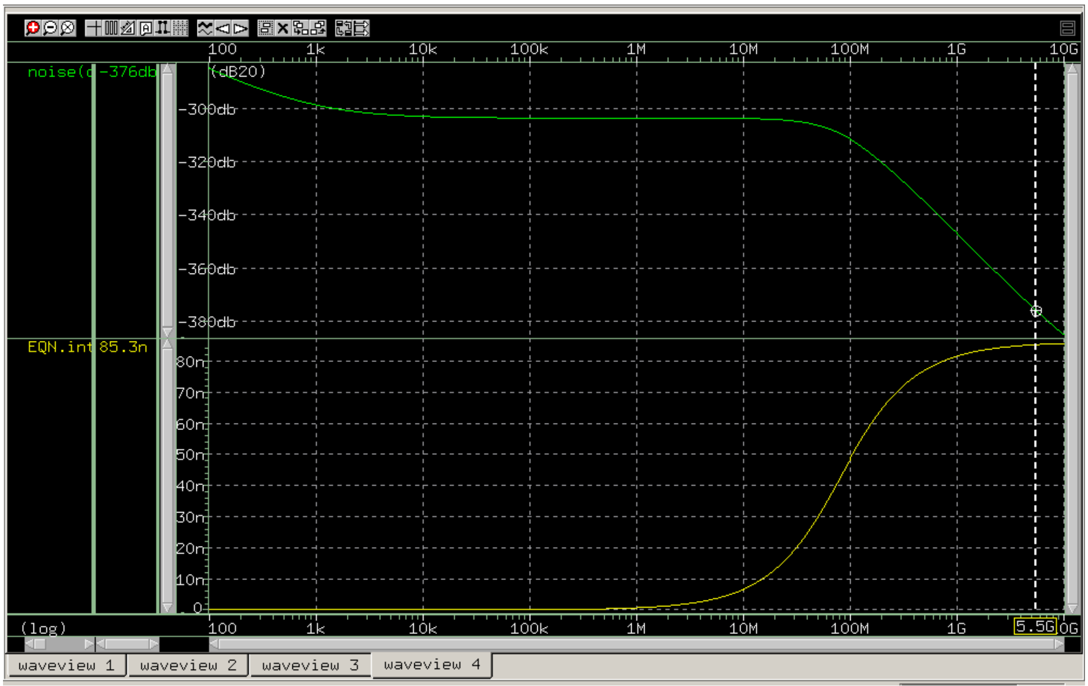
(b) The source follower generates the gain = 0.852 V/V with the corner frequency ≒ 2.5 kHz and the pole frequency of the thermal noise ≒ 55 MHz. The plot is as followed：(including the gain and output noise plot.)

(c) The source follower has lower output flicker noise than the common-source amplifier, but has higher pole frequency of the thermal noise. Since the output flicker noise is proportional to the square of the gain, the common-source amplifier must have higher output flicker noise.

(d) The source follower has higher output noise power than the common-source amplifier. Since the pole frequency of the thermal noise of the source follower is much larger than that of common-source amplifier, the integration of the spectrum of the source follower is therefore larger.



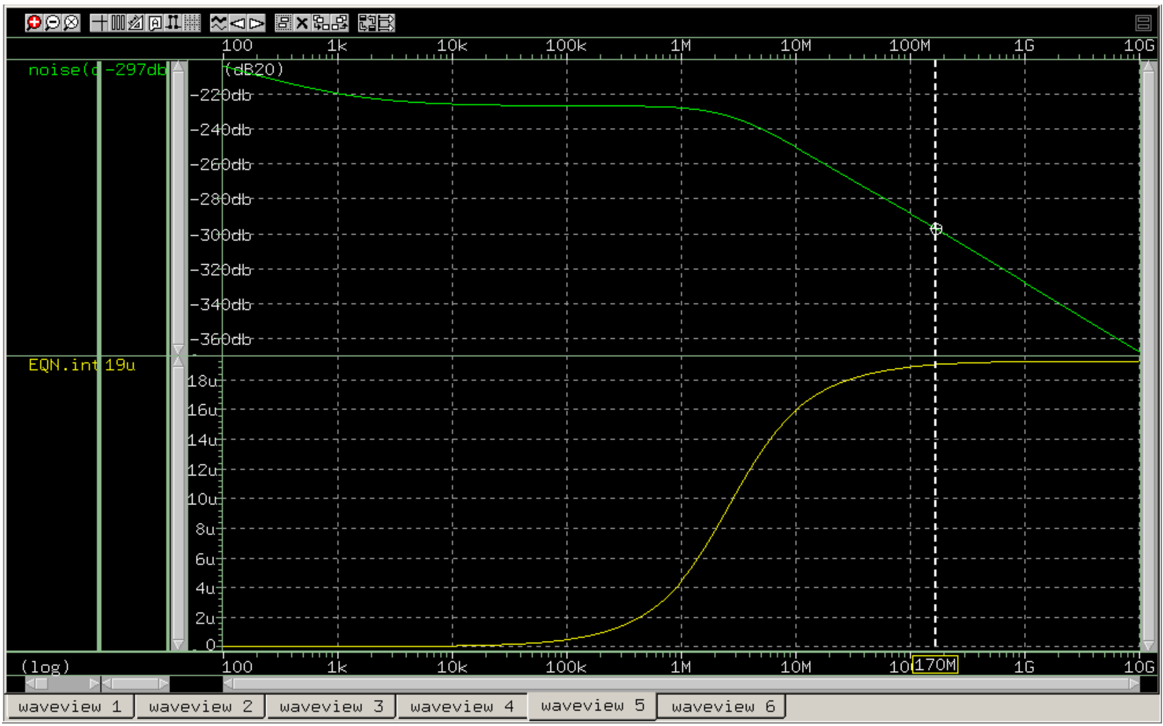
Output noise power of common-source amplifier



Output noise power of source follower

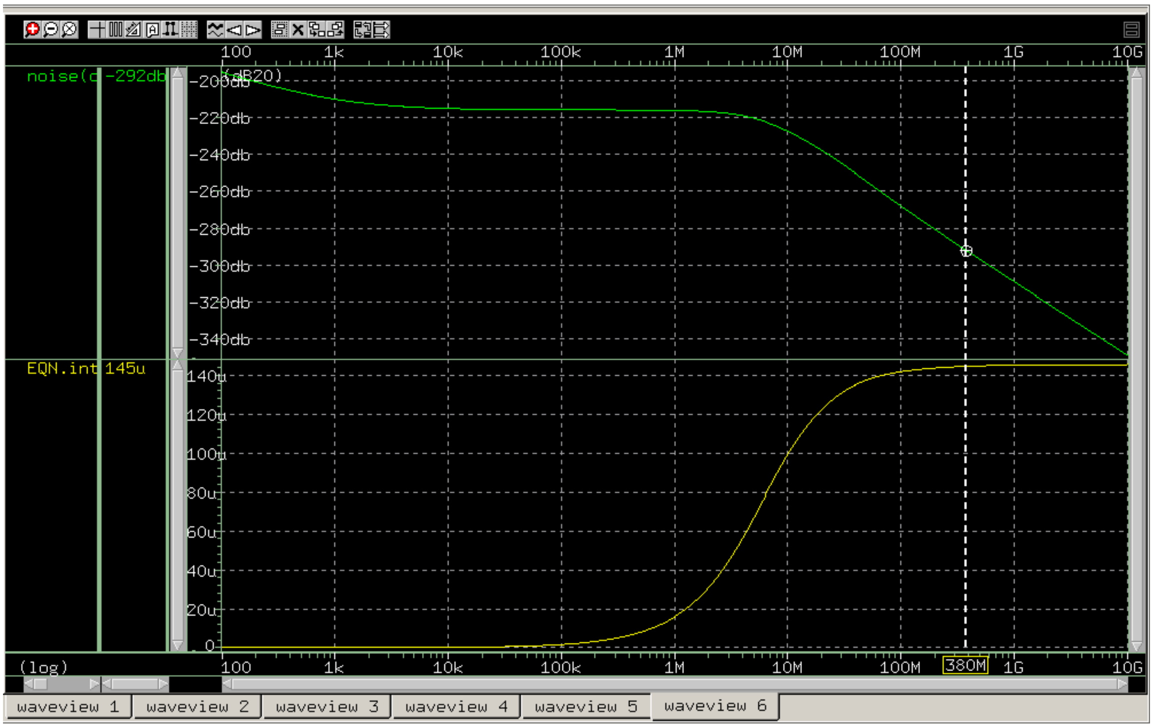
(e) Since input referred noise power = output noise power / A_V^2, the one of common -source amplifier ≒ 5.655 pV^2/Hz while the one of source follower ≒ 117.5 nV^2/Hz. Obviously, the input referred noise power of the source follower is much larger than the one of common-source amplifier due to the low gain of the source follower.

2. (a) The output noise power is as followed：



Since input referred noise power = output noise power / A_V^2, and the gain = 98.6 V/V, the input referred noise power = 19 u / 98.6^2 ≒ 1.95 nV^2/Hz.

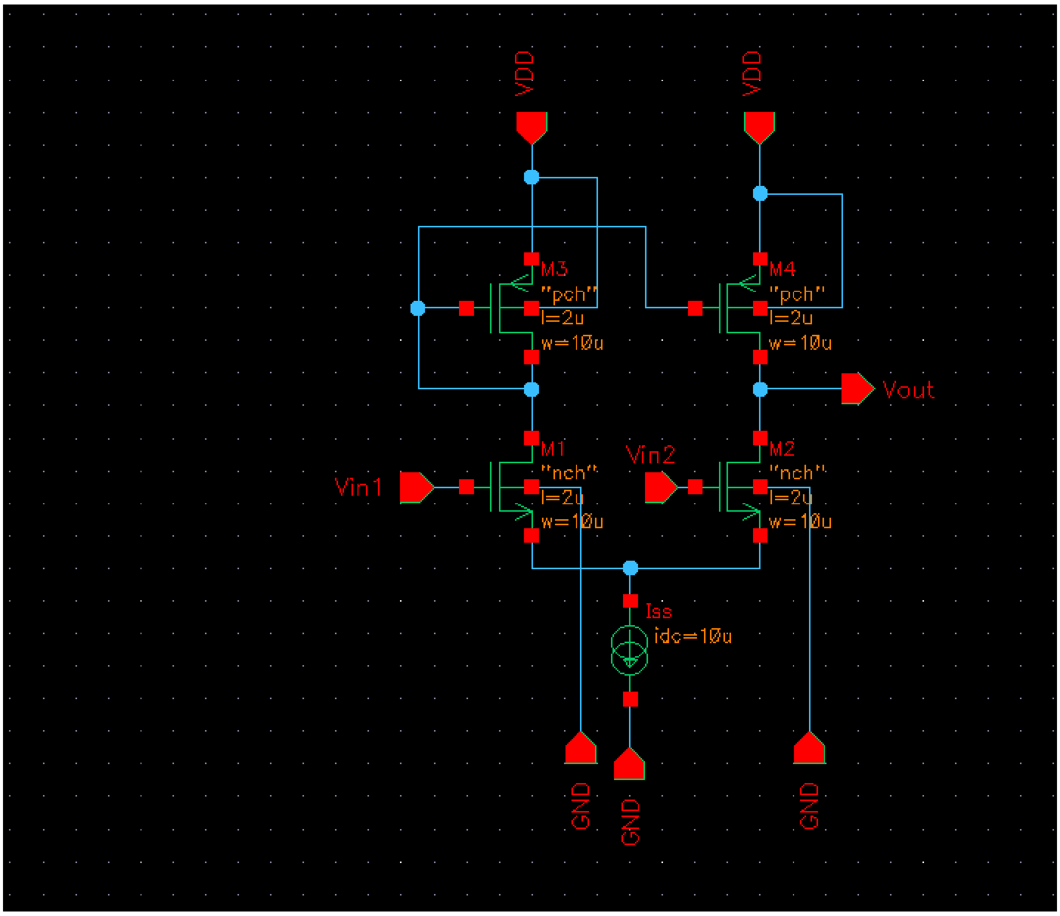
(b) The output noise power is as followed：



Since input referred noise power = output noise power / A_V^2, and the gain = 98.8 V/V, the input referred noise power = 145 u / 98.8^2 ≒ 14.85 nV^2/Hz.

(c) The gain of CS+SF and SF+CS are almost the same, so the most critical factor is the output impedance of the amplifier. To see the output impedance of the amplifier, we can only consider the last stage of each amplifier. Obviously, SF+CS has much larger output impedance than CS+SF (r_o vs. $\frac{1}{g_m}$). Therefore, SF+CS also has much larger output noise power than CS+SF as well as the input referred noise power.

3. Composer：



(a) The gain of the differential to single-ended amplifier is about 55.59; that is, about 34.9 dB. The size of each MOS and the bias points are all in the .lis file.

(b) For output node, the pole frequency = 1/[($r_{o2}//r_{o4}$)*($C_{dtot2} + C_{dtot4}$)] ≒ 33.196 MHz.

For mirrored node, the pole frequency = g_{m3} / C_E ≒ 155.244 MHz where

$C_E = C_{gtot3} + C_{gtot4} + C_{dtot1} + C_{dtot3}$.

For pseudo ground node, the pole frequency = $1/[(\frac{1}{g_{m1}+g_{mb1}} // \frac{1}{g_{m2}+g_{mb2}})*(C_{stot1}+C_{stot2})] \doteqdot$ 1.206 GHz.

subckt	x0	x0	x0	x0
element	1:mm4	1:mm3	1:mm2	1:mm1
model	0:p_18.1	0:p_18.1	0:n_18.1	0:n_18.1
region	Saturati	Saturati	Saturati	Saturati
id	-20.0000u	-20.0000u	20.0000u	20.0000u
ibs	2.003e-21	2.003e-21	-100.5359a	-100.5359a
ibd	355.7974a	355.7974a	-376.5389a	-376.5389a
vgs	-738.9579m	-738.9579m	616.7148m	616.7148m
vds	-738.9579m	-738.9579m	777.7569m	777.7569m
vbs	0.	0.	-283.2852m	-283.2852m
vth	-494.6593m	-494.6593m	441.9987m	441.9987m
vdsat	-231.3067m	-231.3067m	173.8991m	173.8991m
vod	-244.2987m	-244.2987m	174.7161m	174.7161m
beta	690.6926u	690.6926u	1.2501m	1.2501m
gam eff	557.0846m	557.0846m	514.8375m	514.8375m
gm	143.4041u	143.4041u	193.4168u	193.4168u
gds	953.2766n	953.2766n	2.5013u	2.5013u
gmb	44.2946u	44.2946u	32.6869u	32.6869u
cdtot	11.4523f	11.4523f	5.1102f	5.1102f
cgtot	65.2646f	65.2646f	27.2870f	27.2870f
cstot	76.5785f	76.5785f	29.8643f	29.8643f
cbtot	36.6866f	36.6866f	13.4648f	13.4648f
cgs	57.3996f	57.3996f	23.9119f	23.9119f
cgd	3.6110f	3.6110f	1.3944f	1.3944f

(c)

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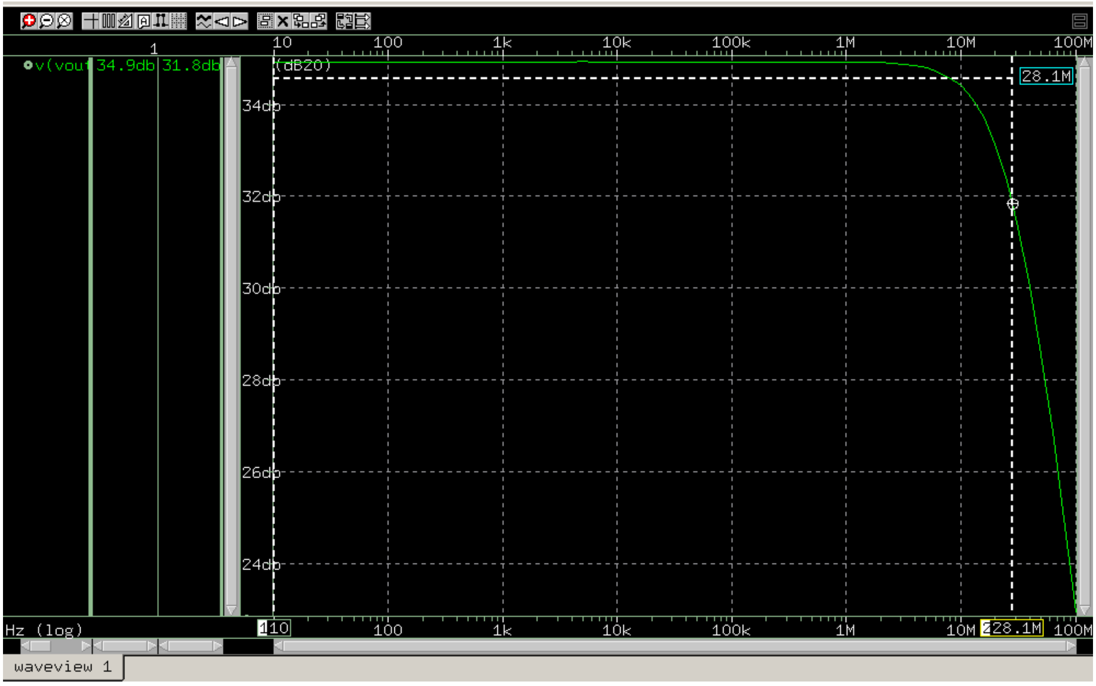
*****************************************************
  ******   pole/zero analysis


   input =  0:vin-          output = v(vout)

      poles (rad/sec)                poles ( hertz)
real             imag             real             imag
-176.847x        0.               -28.1461x        0.
-1.21729g        0.               -193.738x        0.
-7.70292g        0.               -1.22596g        0.

      zeros (rad/sec)                zeros ( hertz)
real             imag             real             imag
-2.19744g        0.               -349.734x        0.
-6.42996g        0.               -1.02336g        0.
68.3915g         0.               10.8848g         0.
```

.pz analysis



Bode plot

Therefore, we can find out that the pole frequency of each pole is slightly different by hand calculation and SPICE simulation since the process of hand calculation is already simplified without considering all the factors. By the way, the pole frequency indicated in Bode plot is the one of output pole.