HW-6

① $R_f = 10K\Omega$, $R_i = 1K\Omega$, $f_T = 10MHz$, $e_n = 10nV/\sqrt{Hz}$, $i_n = 1pA/\sqrt{Hz}$

a) $e_{nRi,out} = -\frac{R_f}{R_i} e_{nRi} = \frac{-R_f}{R_i}\sqrt{4KTR_i}\ \frac{V}{\sqrt{Hz}}$

$e_{nRf,out} = e_{nRf} = \sqrt{4KTR_f}\ V/\sqrt{Hz}$

$e_{na,out} = \left(1+\frac{R_f}{R_i}\right)e_n\ V/\sqrt{Hz}$

$e_{n,out} = \sqrt{e^2_{nRi,out} + e^2_{nRf,out} + e^2_{na,out} + (R_f \cdot i_n)^2}$

$e_{n,out} = \sqrt{\frac{R_f^2}{R_i^2}4KTR_i + 4KTR_f + \left(1+\frac{R_f}{R_i}\right)^2 e_n^2 + R_f^2 \cdot i_n^2}$

$e_{n,out} = 118.36\ nV/\sqrt{Hz}$

$e_{n,in} = \frac{e_{n,out}}{A_{CL}} = \underline{\underline{11.8\ nV/\sqrt{Hz}}}$

b) $f_{ENB} = ?$

$\beta = \frac{R_i}{R_i+R_f} = \frac{1}{11}$

$f_{ENB} = \frac{\pi}{2}\beta f_T = \underline{\underline{1.43\ MHz}}$

$V_{n,out(rms)} = \sqrt{e^2_{nout} f_{ENB}} = 141\ \mu V$

$V_{n,in(rms)} = \frac{V_{n,out(rms)}}{A_{CL}} = \frac{141}{10}\mu V = \underline{\underline{14.1\ \mu V}}$

(2) (c) Datasheet

ADA 4898 $e_n = 0.9 nV/\sqrt{Hz}$ @ $f = 1 KHz$

$i_n = 2.4 pA/\sqrt{Hz}$ @ $f = 1 KHz$

Current Noise density = 10 · Voltage Noise = ~~RS~~

$R_S i_n = 10 \cdot e_n$

$R_S = \frac{9 nV/\sqrt{Hz}}{2.4 pA/\sqrt{Hz}} = 3750\,\Omega$

$\Rightarrow \quad e_{n,out} = i_n R_S$ —— (1)

From simulation: $e_{n,out} = 11.04 nV/\sqrt{Hz}$

from (1), $i_n = \underline{\underline{2.94 pA/\sqrt{Hz}}}$

The simulated value of input current noise density exceeds the expected value. This is most likely due to the frequency dependence of noise density

(d) i) AD 8691:

$e_{n,out} = e_{na} = 0.8 nV/\sqrt{Hz}$ @ $f = 10 KHz$, $\beta = 1$, $f_T = 1 MHz$

$V_{n,out} = \sqrt{e_{n,out}^2 \times 10^6} = 8 \cdot \mu V$

Simulated Value = $8.32 \mu V$

ii) ADA 4898:

$e_{n,out} = 0.9 nV/\sqrt{Hz}$

$V_{n,out} = \sqrt{e_{n,out}^2 \times 10^6} = 0.9 \mu V = 900 nV$

Simulated Value = $919.86 nV$

The error is most likely from ignoring the '1/f' contribution

Problem 1)

c)

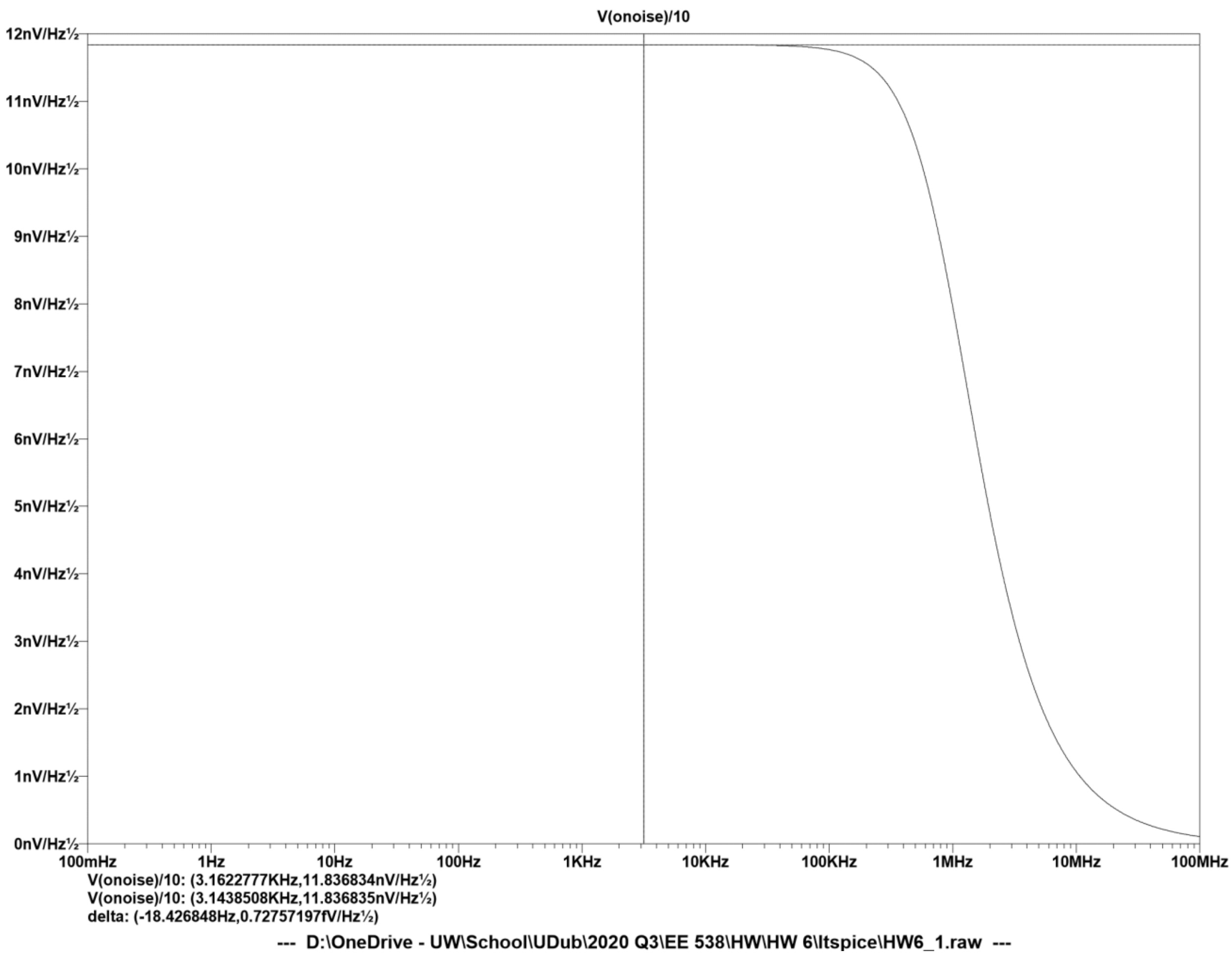


Fig 1. Input Referred Noise Voltage Density plot

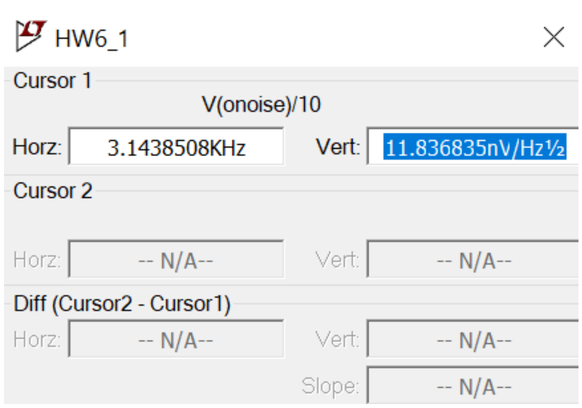


Fig 2. Input Referred Noise Voltage Density

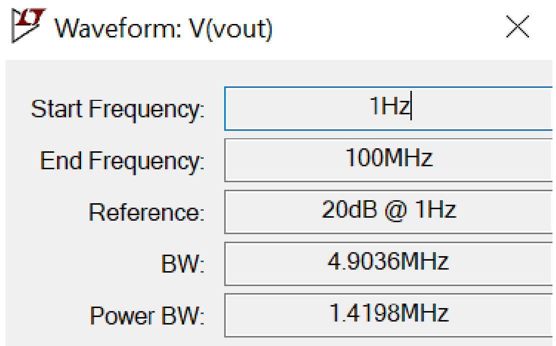


Fig 3. Equivalent Noise Bandwidth (F_{ENB})

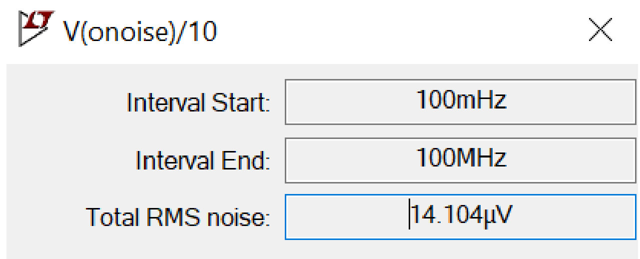


Fig 4. Input referred RMS noise voltage

Problem 2)

a)

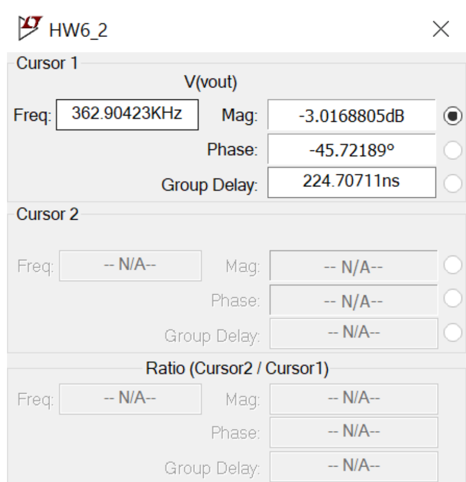


Fig 5. F_{3dB} frequency of AD8691

Noise Bandwidth = $\pi/2 * f_{3dB}$ = 570 KHz

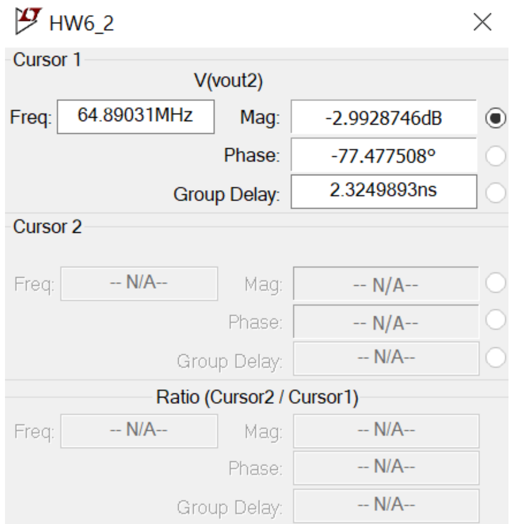


Fig 6. F_{3dB} frequency of ADA4898

Noise Bandwidth = $\pi/2 * f_{3dB}$ = 102 MHz

b)

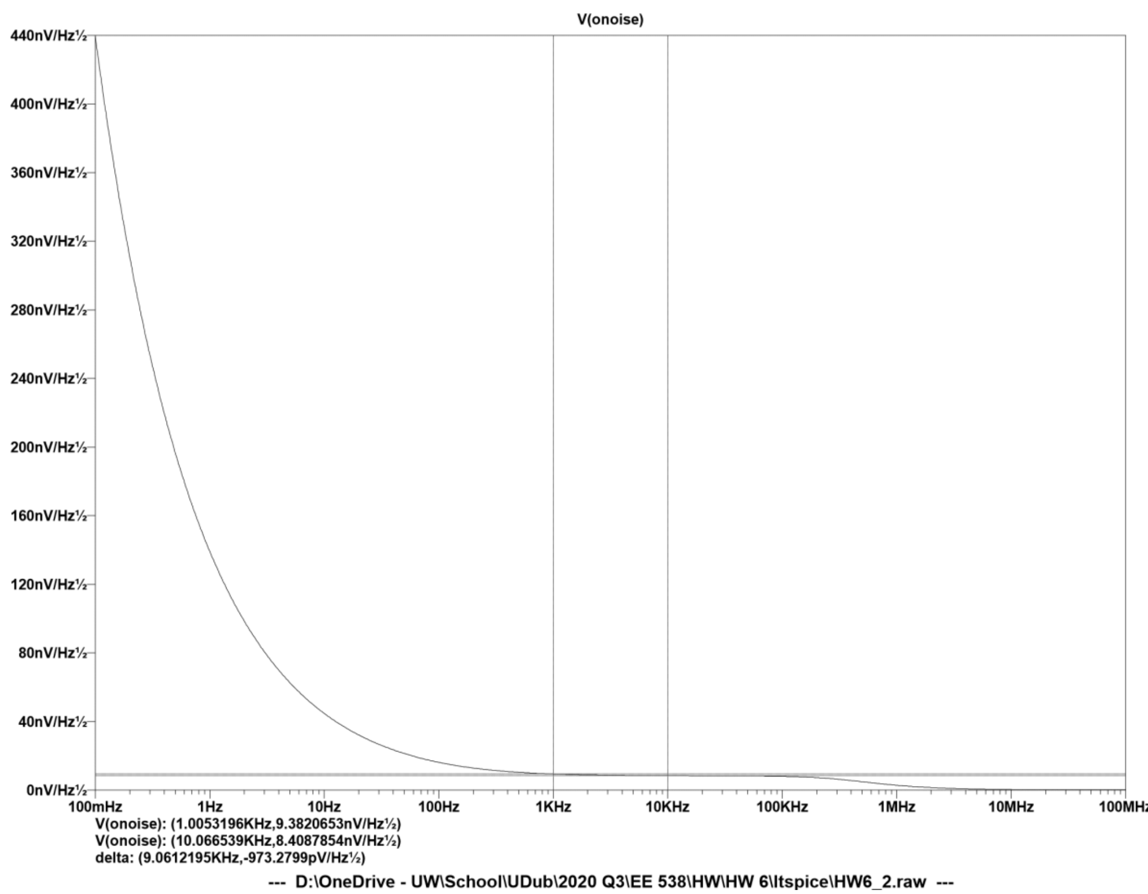


Fig 7. Noise voltage density of AD8691

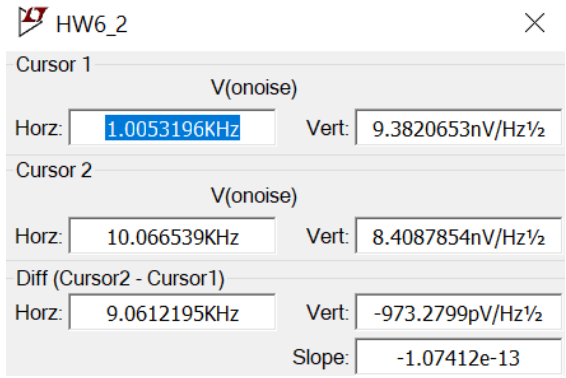


Fig 8. Noise voltage density of AD8691 at 1KHz and 10KHz

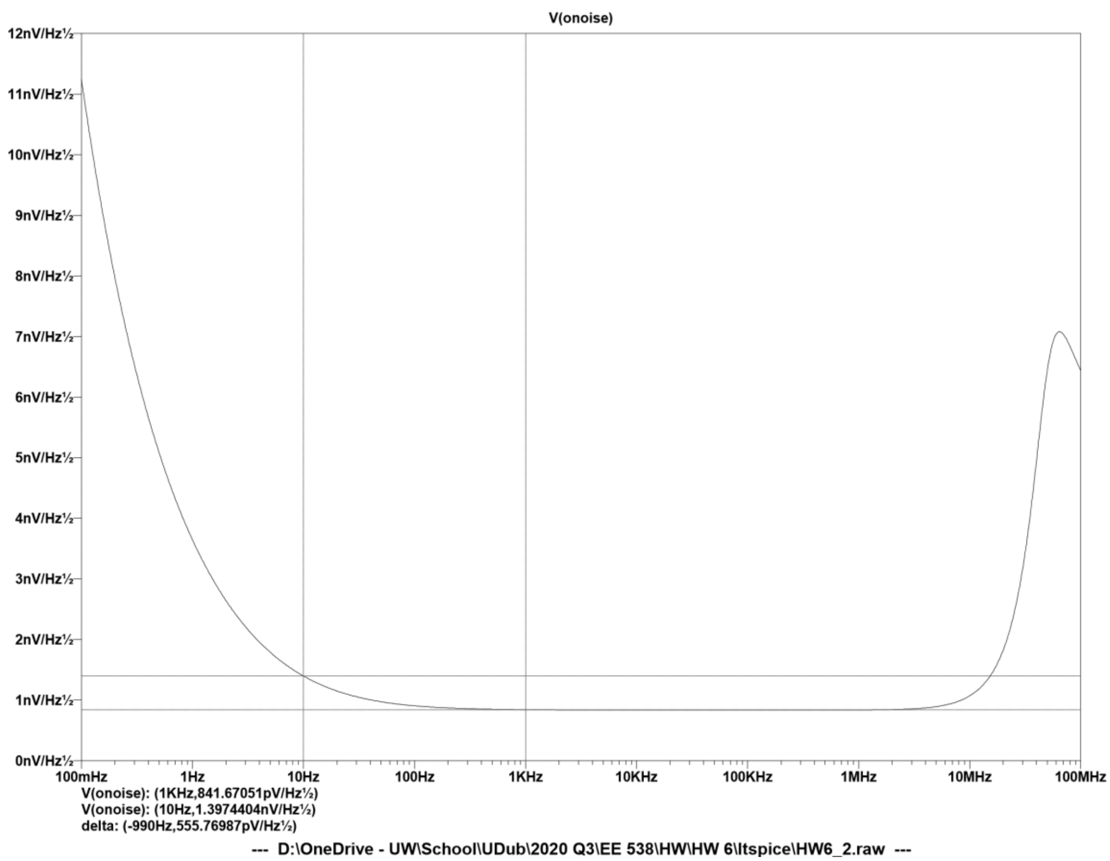


Fig 9. Noise voltage density of ADA4898

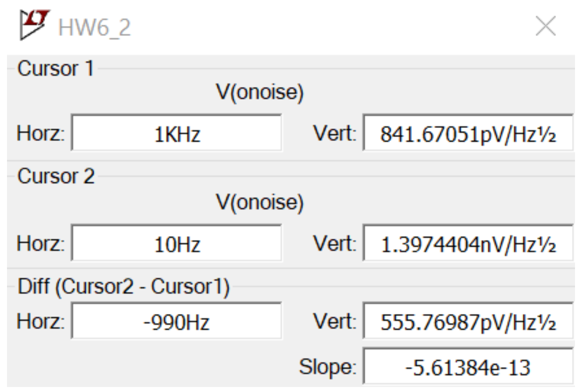
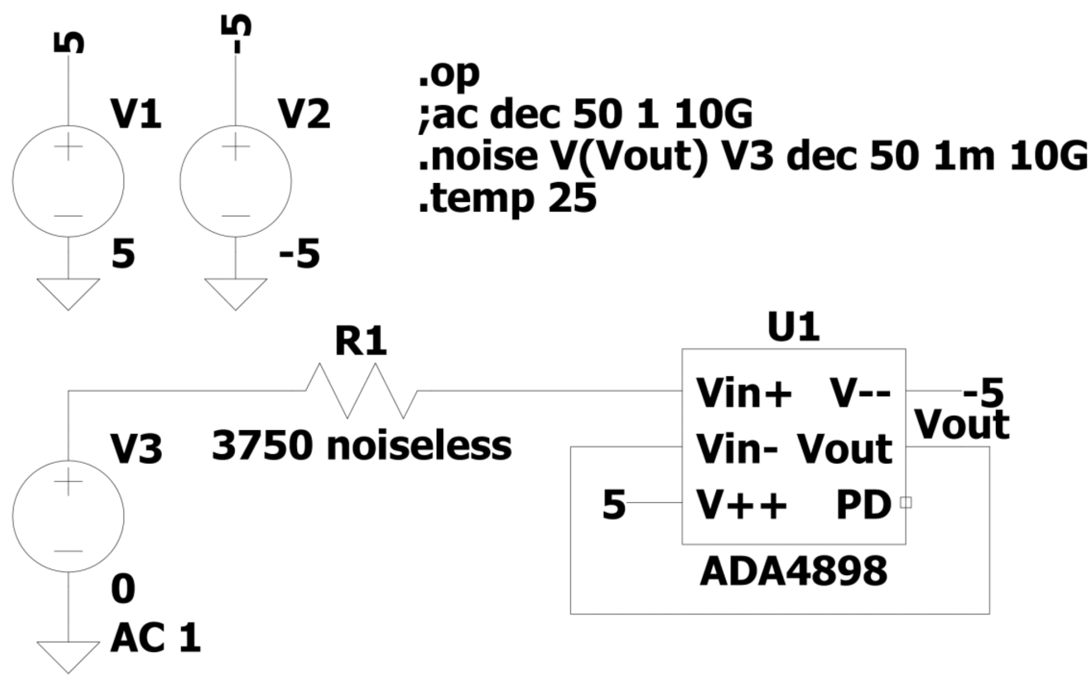


Fig 10. Noise voltage density of ADA4898 at 10Hz and 1KHz

c)



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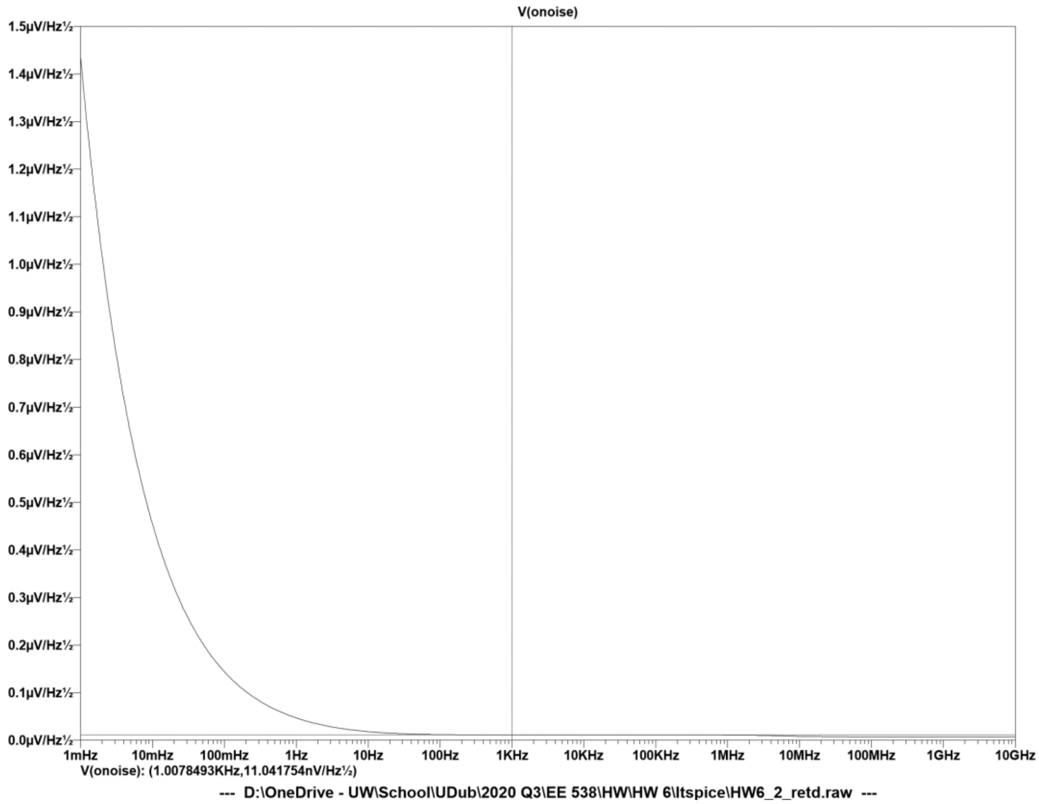

Fig 12. Noise voltage density of ADA4898

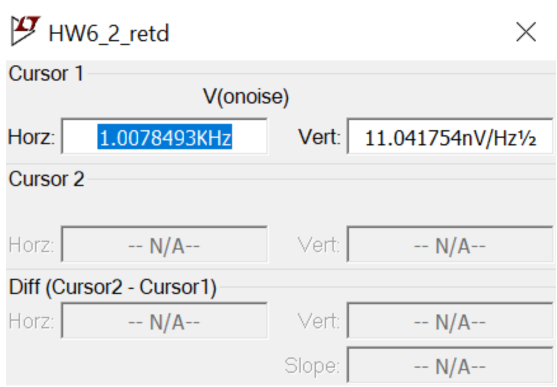

Fig 13. Noise voltage density of ADA4898 at 1KHz

d)

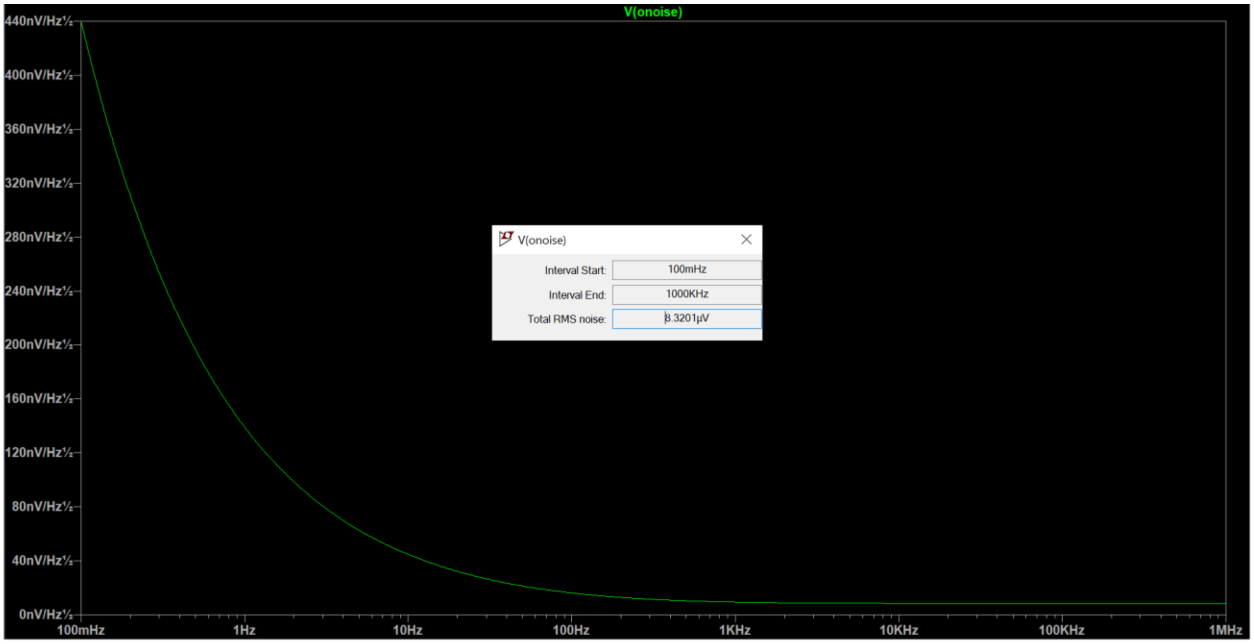

Fig 14. RMS output noise of AD8691

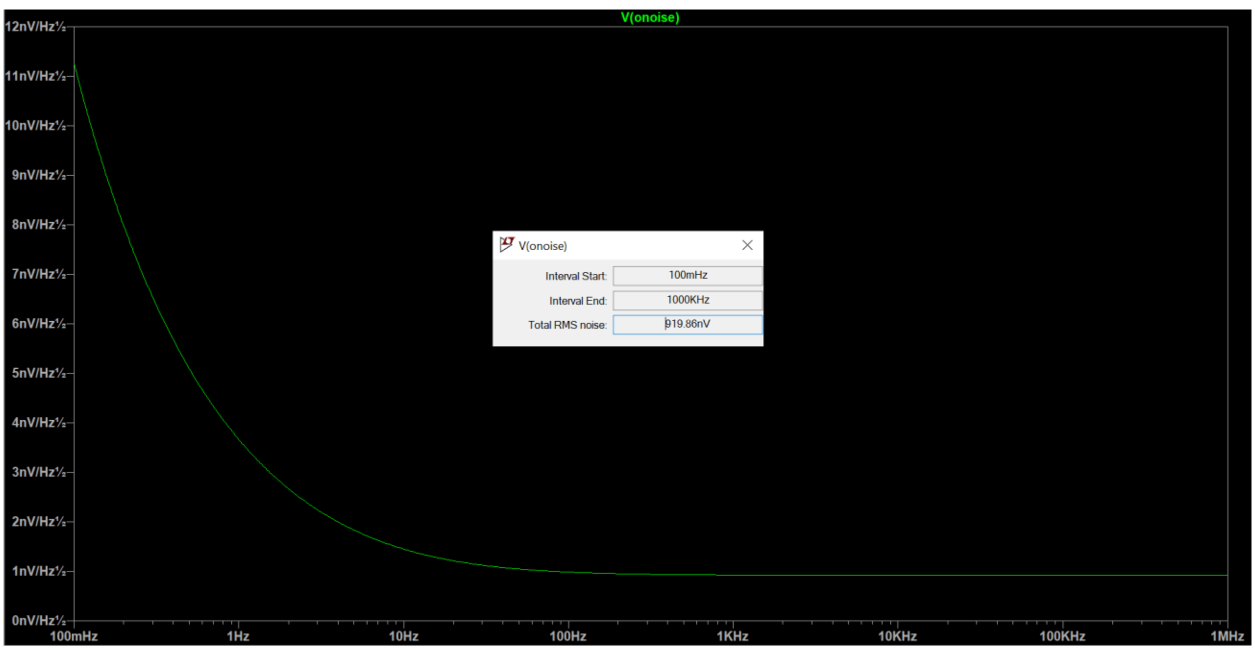

Fig 15. RMS output noise of ADA4898